POWER

A McGRAW-HILL PUBLICATION—ESTABLISHED 1884

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Volume 71 NEW YORK, MAY 27, 1930 *Number 21*

Modern Culture

WHAT is the effect of the graphophone, the radio, the movie, the automobile, and other recent claimants for the time and attention of man on the culture, the mental make-up, the habit of mind of the people of today?

They are all potent for good. The graphophone brings within the reach of the family of moderate means excellent renditions of the world's best music.

The radio permits one from the comfort and quiet of his home to listen to concerts, lectures, discussions of current topics, announcements of general interest, and the views of public men.

The automobile increases man's mobility and makes it possible for him to know from personal visits the points of historic, scenic, and other interest within a large radius, and to mingle with more people.

The movie makes it possible to present to a vastly larger audience much of the inspiration to chivalry and heroism, much of the romance and tragedy, all that reaches down to the depths of human feeling that drama and literature have presented to older and smaller groups.

And in the news section it permits millions to get a visual representation of passing events quite different from the conception that would come from reading accounts of them in the newspapers.

The press with its wonderful utilization of modern facilities for news gathering and pictorial presentation places within the reach of all a circumstantial daily account of the passing show. The bookstalls and newsstands teem with popular editions of standard works, magazines of every grade of literary excellence and every type of content.

What has been the effect of a decade or two of this régime on the state of mind of the people?

Has the average citizen a better estimate of men and measures than he used to have? Has he a broader knowledge of what the world is like and what is going on in it? Does he know more and better music and literature? Is there a more informed public opinion, capable of passing reasoned, unimpassioned judgment upon passing problems? Are the full potentialities of these new cultural facilities being impressed into a fuller and healthier public consciousness, or are they running too much to joyriding, sensationalism, jazz, and nigger dialect?

EDITORIAL

Economics of Power Generation and Supply

REFINEMENTS in power generation have reached the stage where large central stations, operating on the usual condensing cycle, may expect little further gain in efficiency without incurring fixed charges that will offset such gains and also may involve undesirable complication. The heat wasted to the condensing water is the big loss remaining, and further efforts toward economy must concern conservation in this direction.

On the other hand, many industrials that require large quantities of steam for process have taken advantage of the advance in high-pressure steam generation. Employing extraction or high-back-pressure turbines exhausting to process, they are producing power at extremely low cost. Moreover, many of the modern industrial power plants have incorporated refinements comparable with those found in central stations.

When the steam and power demands coincide and balance, the most economical conditions exist for the industrial plants, and central station service is of no advantage. Such ideal conditions seldom obtain, however.

Where such a balance does not exist, its approximation is sometimes sufficient to preclude central station service in the usual form, yet such plants do not attain all the economy desired. Then, too, opportunities often exist for industrials to purchase part of their power or pool their service and demands with other industrials or with central stations, thereby eliminating the waste incident to independent operation.

IT IS, of course, possible to balance between steam and power loads in the industrial plant to the neglect of other factors, but this is generally inadvisable. Size has much to do with the ability of an industrial plant to generate its own power economically. Again, changed conditions of fuel supply may shift the economic balance between purchased and locally generated power. Natural gas affords an excellent example of this.

Extension of natural gas lines, which is now being made over great distances and large areas in the South, Middle West, and California, will make this desirable fuel available to many industrials that heretofore could obtain fuel only of an inferior quality or at high cost. If the price of gas is attractive, as seems probable in some localities, it will provide an incentive for many industrials now purchasing power to put in their own plants. Some such installations

will be fully justified; whereas others will probably have been ill considered. The central stations should meet this situation according to the economic facts involved in each individual case, regardless of whether the answer be purchased power or power privately generated from gas supplied by some utility.

PROCESS steam required by some industries exceeds the amount necessary for their power supply. With this condition is coupled the fact that better economy results when steam is generated at comparatively high pressure and delivered to process after it has first been used for the generation of power. In some industries where the process steam requirements are large, in comparison with the steam demand for power, it frequently happens that steam is generated without regard to byproduct power possibilities and the savings that could be effected. This represents waste.

In order to meet conditions such as these a new type of central station has lately come into existence whereby both steam and power are supplied by the utility, and byproduct power not used by the industry is fed into the utility system. Such a station may supply a single large industrial or a group of smaller plants.

THERE is a rapidly growing tendency for industrials and central stations to interchange off-peak or seasonal power, and so to utilize waste heat, meet peak loads, or provide emergency service. Examples of this class are often found where industrials have their own hydro plants; also in waste-heat industries such as cement mills, steel works, and lumber mills.

To be successful, the co-operative arrangements require careful individual analysis, and none should be taken as a precedent without investigation. Many have been made under the influence of local conditions, and others would be possible were not the sales policies of some companies hampered by inflexible rate schedules.

Contractual relations are quite difficult to formulate so that all contingencies may be covered and that the agreement may be equitable to both parties. These facts, and the thought of establishing a precendent that may not always be applicable, have been responsible for some utility and industrial executives to approach the subject with caution. But the time has arrived for realization that where potential savings exist and where some of this waste may be saved the obvious thing is to co-operate. This should be predicated on profit to both parties.

Many plants do not offer such opportunities, but where there are indications of their existence careful studies are warranted. With all cards on the table, and with mutual confidence, frank discussion will usually result in a satisfactory and profitable arrangement for all concerned.

THESE new co-operative relations are definitely under way. They will move ahead wherever practicable, for the simple reason that economic law will, in the long run, find practical expression.

Thus *Power* draws attention to some of these problems to the end that more economical generation of power shall be furthered. Space permits the inclusion of only a few existing installations that are typical of the several cases involved. Many others could be cited.

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POWER *Stands for . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

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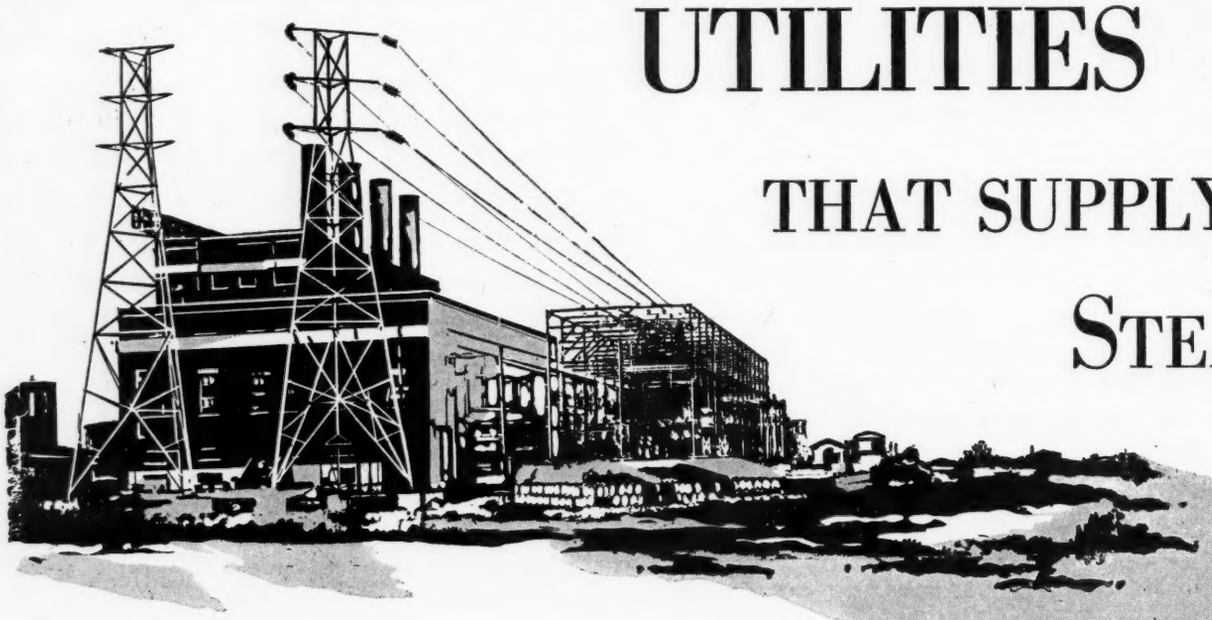
UTILITIES THAT SUPPLY STEAM



Ability of the utility to supply a complete service—steam and power—will sometimes make purchased service cheaper than local generation to the large process-steam using industrial and at the same time leave a margin of profit for the utility furnishing it

CERTAIN types of industrial plants—particularly textile finishing plants, oil and sugar refineries, soap factories, chemical plants and paper mills—require large quantities of steam for process work. In addition, in the northern part of the United States, industries require steam for building heating for at least six months of the year. Regardless of the source of power supply, they must install boilers and complete boiler room equipment, if steam cannot be purchased.

Thus the investment chargeable to power generation in such plants includes only the turbine room investment plus the *additional* cost of a boiler room designed to provide for power production as a partial byproduct of process steam. Operating costs chargeable to power are *additional* fuel, labor and supervision over those required for process and heating steam generation only. The amount of these power costs varies greatly with the type of industry, its size and location.

So much for general principles. What is the actual present situation? In many industrial districts are to be found large and modern manufacturing plants generating their own power along with large amounts of process steam in the face of very favorable power rates to large consumers. Some of these plants are so well situated in respect to power generation that the utilities concerned have agreed that power cannot be economically purchased by them so long as huge quantities of process steam must be generated locally. This, it should be emphasized, is not a generalization, but simply a statement of conditions in particular plants in specific localities. In many of these cases a study of the situation has shown that the ability of the utility to supply steam as well as electricity completely changes the picture. The greatest possibility of economic arrangements for outside supply of steam and power exists while the industrial plant is still in the project stage, before money has been invested in steam or power generating equipment, or when rapid growth or obsolescence would shortly demand a complete revamping.

With rare exceptions, the utility, from the mere size of its plants, can generate any given combined steam and power load more cheaply than can an industrial in the same locality. Selling price is, of course, a different matter, for this must include transmission losses and fixed charges, and profit. The utility, on the other hand, can benefit by the diversity factor of its many outlets. Considering all of these factors, there are certainly many cases where the utility can furnish a complete steam and electric service to the industrial at a total cost representing a saving to the industrial and a net profit to the utility.

A large outlet for steam close to the utility plant will generally be an essential feature of such arrangements. In fact, the cost of long steam-transmission lines will ordinarily require the location of the generating station close to the industrial steam load. Ability of the utility to generate and *sell* all of the available byproduct power may have an important influence on the combined cost of steam and electricity.

The division of charges between steam and electric services will vary with the accounting assumptions made. This division is, however, a minor concern to the consumer of both services, and he should be satisfied with any reasonable division as long as his combined costs are satisfactory.

It must be recognized that the purchase of both steam and electricity shifts a heavy investment burden from

industrial to utility. The contract and rate arrangements must take account of this fact. It is not simply a matter of demand charges. Attention must be given to the business stability of the industrial plant or the industrial group served, and the risk involved must receive contractual recognition exactly as if the money were invested directly in the industrial enterprise. Unless condensing water is available at the station site, the erection of a central station to supply steam from back-pressure turbines to an adjacent group of industrials directly ties the utility's investment to the future prosperity of the group. These matters will be more fully considered later in the article on contractual relations.

The present trend, under suitable conditions, toward the supply of both steam and electricity by the utility is best understood by a study of important examples. For the purpose of such study, four outstanding cases have been selected. These will be reviewed briefly, omitting general descriptive matter not definitely related to the subject under consideration.

First may be considered a case where this type of relation has been maintained for some years to the satisfaction and profit of all concerned.

For many years the Rochester Gas & Electric Company, Rochester, N. Y., has been supplying steam for heating and manufacturing from its Station 3, situated in the center of the manufacturing district. In the last five years two additional plants have been built—one (Station 8) for supplying steam to the downtown business section of the city, the other (Station 9) designed purely for supplying industrial plants. A 5,000 kw. turbine is installed in Station 8, and 3,000 kw. in Station 9. These are back-pressure, bleeding units normally controlled by pressure, but with emergency speed control. The Rochester Gas & Electric Company now has an installed capacity of non-condensing units totaling 12,000 kilowatts.

Referring to steam and electric supply, R. D. DeWolf, of that company, writes, "With boiler pressures of 350 to 450 lb., the turbine manufacturers are today in position to supply highly efficient units equipped with automatic back-pressures governing devices so designed that the turbine will carry whatever electric load is necessary to maintain any desired exhaust or bleeder pressure, irrespective of the variation in demand for steam.

"In an emergency these turbines may be operated on speed control to deliver their full rated kilowatt capacity to the electric system in order to meet unexpectedly heavy loads or to replace loss of generating capacity at some other point on the system. Any excess steam required under these conditions above the heating and industrial demand at such times would have to be exhausted to the atmosphere.

"The public utility supplying a service of this type has to meet a very wide diversity of loads. The maximum power demand and the maximum steam demand rarely occur simultaneously.

"This combined service enables the industrial consumer to eliminate entirely any power plant investment; relieves him of the supervision of a power manufacturing process in which he is not an expert; makes available for manufacturing or other purposes the space which would otherwise be required for the power plant; simplifies his labor situation, and reduces his labor turnover. Being connected with a plant of large steam generating capacity, his varying individual demands are met without any difficulty on his own part. Rapid expansion of his business does not mean additional financing for his power plant. Thus he is enabled to devote all of his often not-too-easily-acquired additional capital to the development of his own business.

"In 1929 Rochester generated over a billion and a half pounds of steam supplied to consumers of all types, the individual demand varying from a maximum consumption of twenty million pounds per month down to a few hundred thousands pounds a month. Some 9,600,000 kw.-hr. was generated by this steam before it was supplied to approximately 260 consumers.

"Over 600 trouble calls from our consumers were taken care of by our inspectors and steamfitters. As in our electric service, most of these were troubles for which we were not directly responsible, most of them originating in the consumer's equipment. Satisfactory operation for the consumer and sale of a proper amount of steam by the utility were both, however, contingent upon the correction of the trouble. In addition, we have frequently advised our consumers regarding changes to be made in their steam-using

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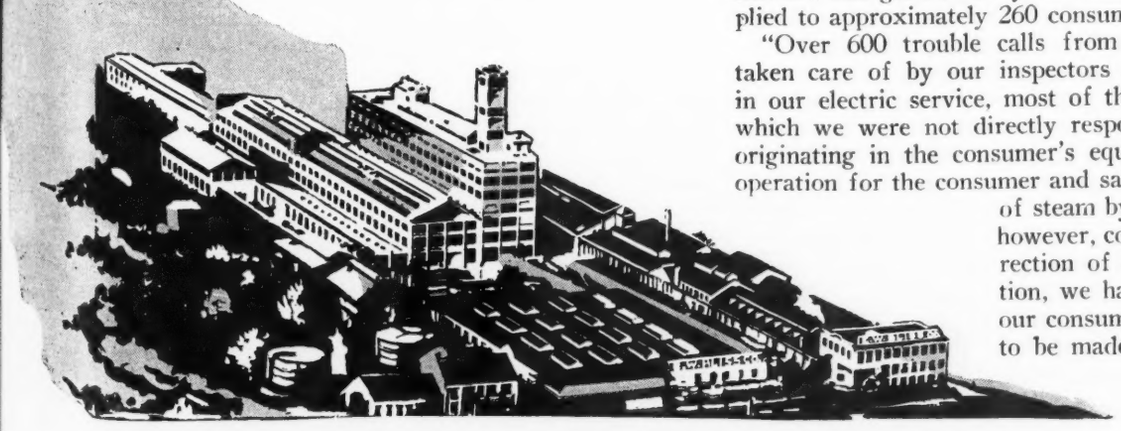
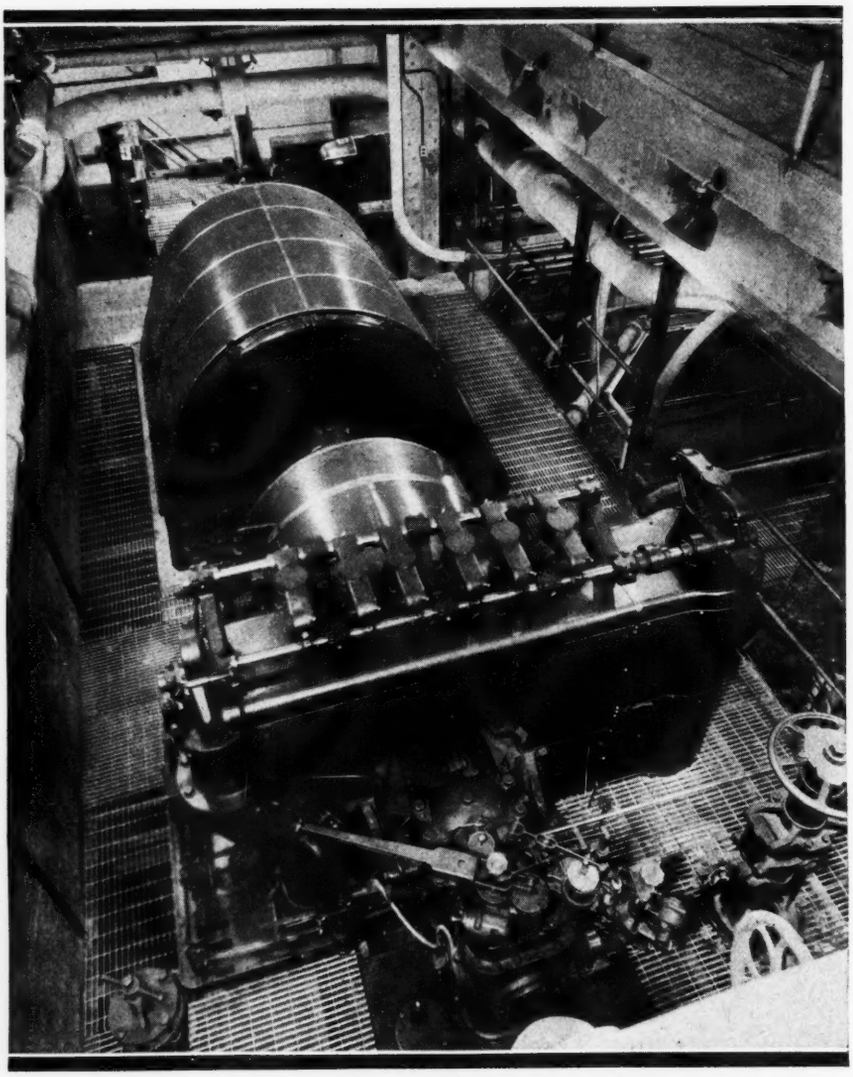
TO

INDUSTRY



equipment or other improvements which would better their operation and reduce their operating expense."

The Rochester development involves two kinds of service: that of the district-steam type, where many industrials and public buildings receive steam from a single plant, and also central stations erected to supply steam to individual large industrials. The latter development is more recent. Such a plant naturally supplies electricity to its steam customer, but with the entire distribution system as an outlet for any excess electricity generated. Conversely, when the local electrical demand exceeds that which can be generated as a byproduct of the local steam load, the additional power may be fed in from the system.



This 5,000-kw. turbine at the Lawn St. plant of the Rochester Gas & Electric Corporation exhausts to industrial lines

THE NEWEST PLANT to generate by-product power only has just been completed at Baton Rouge for the Louisiana Steam Products, Inc., a constituent company of Engineers Public Service Company, which also controls the Baton Rouge Electric Company and the Gulf States Utilities Company, with its large interconnected system extending from Baton Rouge westward across Louisiana and far into eastern Texas. Work on this station, designed and built by Stone & Webster Engineering Corporation, was started in November, 1929. It will supply all power and steam requirements of the near-by refinery of the Standard Oil Company of Louisiana, one of the largest in the world.

Viewing the general installation at Baton Rouge one might be inclined to consider it justified solely by the opportunity offered to generate and completely utilize a large amount of byproduct power. A brief review, however, reveals contingent factors which were of definite importance in determining the economic soundness of the project, and emphasizes the necessity of studying all of the many influencing factors when considering a project of this nature.

The refinery was faced with the necessity of making extensive changes to provide for growth in both steam and electric loads, and to permit the retirement of some of its older boilers.

The utilities likewise felt the need for increased generating capacity at the eastern end of the interconnected system. The one generating station at Baton Rouge was of limited capacity in relatively small units served by a spray pond. Power transmitted 185 miles from the Neches Station at Beaumont, Texas, supplemented the supply from this station. The rise and fall of the Mississippi River of approximately 46 ft. made it difficult and expensive to construct a new condensing station for increased capacity required at the eastern end of the system. Therefore, a non-condensing station supplying steam and power to the refinery and surplus power to the utility offered a definitely advantageous solution of the problems confronting both companies.

The location and requirements of the refinery were unusually favorable to the plan adopted. Its large process steam demand is utilized at the remarkably high yearly load factor of 83 per cent, and its large electrical energy consumption is at a load factor of 85 per cent.

Another consideration was that the dual-purpose station could be located adjacent to the river to permit of expansion by installation of condensing turbines at some future date, if this should become desirable. The site for the new station could be chosen to permit of relatively short steam lines and also be adjacent to undeveloped areas available for future industrial development.

Surplus byproduct power is available to be fed back into the system of the Gulf States Utilities Company at an almost constant rate and this high-load-factor generation is matched by a similar high-load-factor demand for power used for such purposes as pipe line pumping.

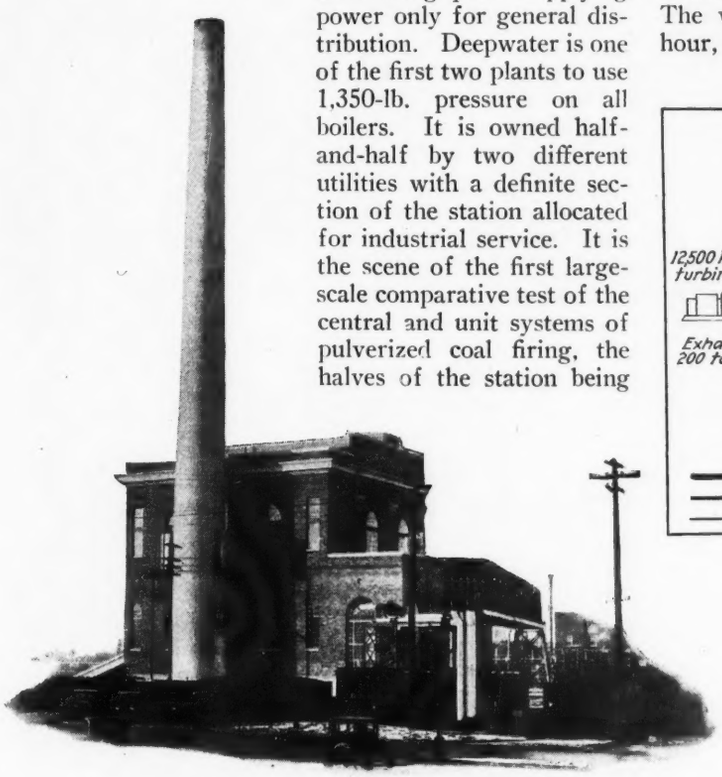
Publication of complete technical details of the new station is being withheld for a later date. It may be mentioned, however, that the fundamental requirement of being able to burn all available refinery residuals added appreciably to the difficulties of its design. The furnaces and fuel-burning equipment are designed to permit of firing pulverized petroleum coke, acid tar, lubricating sludge and natural gas simultaneously.

The initial installation contains four boilers, each having a capacity of 350,000 lb. per hour generated at 670-lb. working pressure. This steam is delivered at 750 deg. F. to three 15,000-kw. turbines exhausting to process at 141-lb. gage pressure. There is no return of condensed steam from the refinery. Boiler make-up, of approximately 75 per cent, is handled by a specially designed feed-water treatment plant.

In accordance with usual custom the station might be termed a 45,000-kw. plant. This, however, would give a totally erroneous impression of the service which it is to render, since the installed boiler capacity is sufficient to furnish steam for a load of about 140,000 kw., if supplied to condensing units.

DURING the past year the most-discussed utility installation generating process steam as well as power has been Deepwater Station, situated near Penns Grove, on the New Jersey side of the Delaware River.

Supply of steam to an industrial is, however, only one of many novel and interesting features of this station, which is, in the main, a condensing plant supplying power only for general distribution. Deepwater is one of the first two plants to use 1,350-lb. pressure on all boilers. It is owned half-and-half by two different utilities with a definite section of the station allocated for industrial service. It is the scene of the first large-scale comparative test of the central and unit systems of pulverized coal firing, the halves of the station being



Lincoln Park plant (Station 9) of Rochester Gas & Electric Corporation supplies steam and power to three industrials

equipped, respectively, with the two systems. Further discussion of this plant will, however, be confined to those factors that bear on the general subject under discussion—the supplying steam and power to an industrial plant.

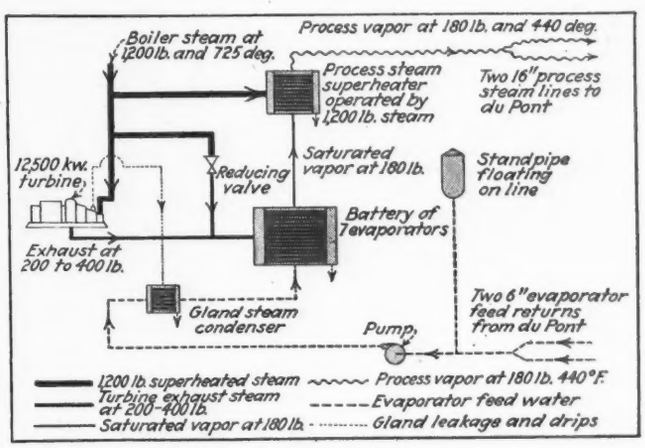
The Deepwater project involves special co-operative relations among several interests. The plant is owned jointly by the Deepwater Light & Power Company, organized by the United Gas Improvement Company, and the Atlantic City Electric Company, a subsidiary of the American Gas & Electric Company. Steam and electricity are furnished, under a special arrangement, to a neighboring large plant of E. I. duPont de Nemours & Company. For the sake of brevity these interest will be referred to hereafter respectively as U.G.I., A.G.&E. and duPont.

Physically, one-half of the station is owned by A. G. & E. and the other by U.G.I. The central section, devoted to equipment allocated to duPont service, is owned jointly by the two utility companies.

In each utility section is a 53,000-kw. cross-compound condensing turbine-generator supplied with steam at 1,200-lb. pressure and 750 deg. from two 1,350-lb. pressure boilers, one a reheat boiler. The duPont section is provided with two 1,350-lb. boilers supplying steam to a 12,500-kw. high-pressure non-condensing turbine similar to the high-pressure cylinders of the 53,000-kw. utility turbines. Space is provided for a duplicate duPont unit if it should be required later.

Each utility section can be extended out from the center without disturbing the other or the duPont section.

The entire exhaust of the duPont turbine passes (at some pressure in the range from 200 lb. to 400 lb.) to a battery of seven evaporators, where it is condensed and returned as distilled feed water for the duPont boilers. The vapor produced, never exceeding 400,000 lb. per hour, is superheated to 440 deg. F. in a reheater fed by


Boiler steam at 1200 lb. and 725 deg.
Process vapor at 180 lb. and 440 deg.
Process steam superheater operated by 1200 lb. steam
Two 16" process steam lines to du Pont
12500 kw. turbine
Reducing valve
Saturated vapor at 180 lb.
Standpipe floating on line
Battery of 7 evaporators
Exhaust at 200 to 400 lb.
Gland steam condenser
Pump
Two 6" evaporator feed returns from du Pont
1200 lb. superheated steam
Turbine exhaust steam at 200-400 lb.
Saturated vapor at 180 lb.
Process vapor at 180 lb. 440°F.
Evaporator feed water
Gland leakage and drips

Deepwater supplies process vapor to the duPont plant from evaporators heated by the turbine exhaust

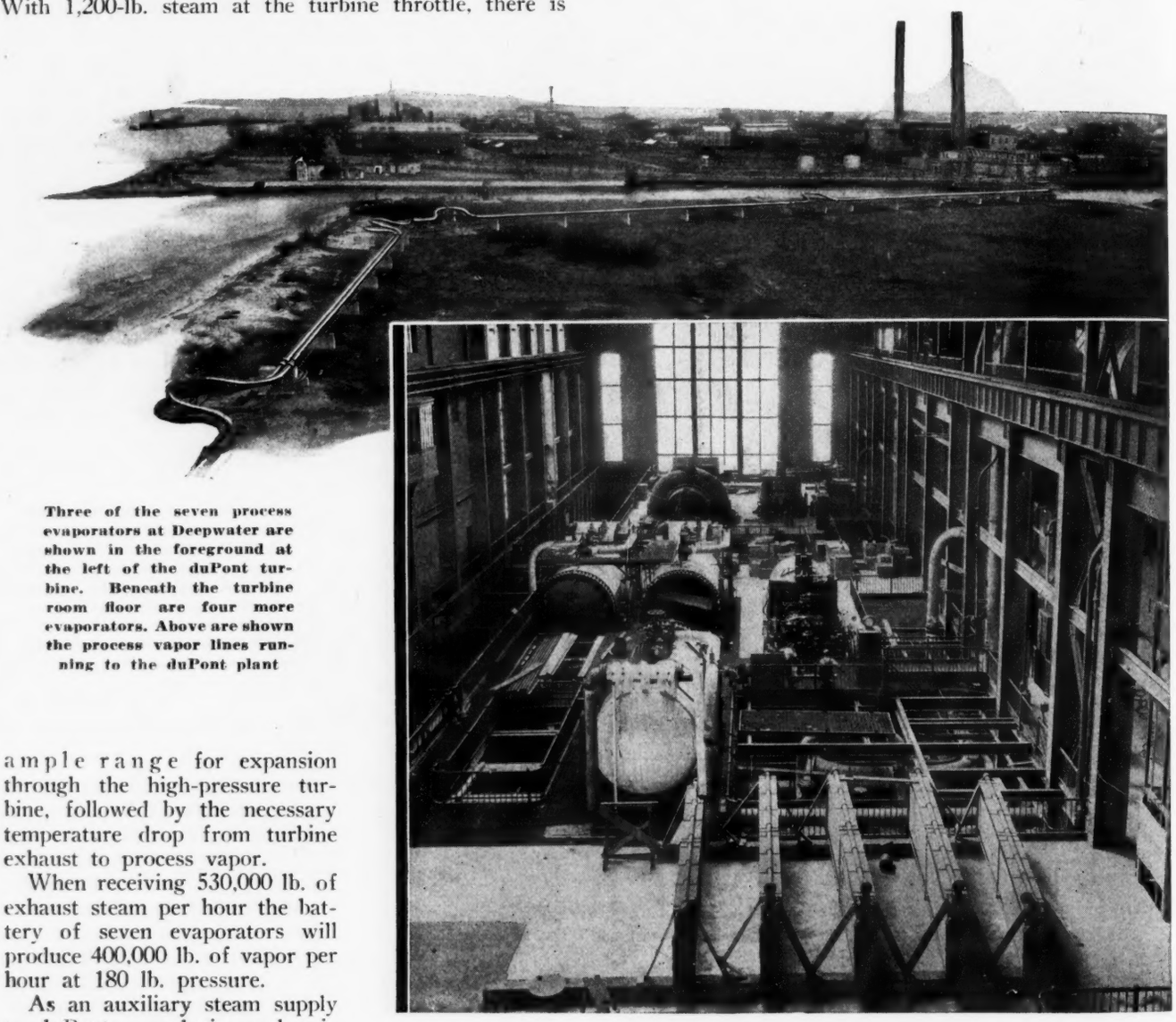
1,200-lb. steam. It then passes to the duPont process lines. As feed for this evaporator duPont sends back a mixture of process returns and make-up water equal in weight to the vapor consumed.

The arrangement with the duPont company is novel. Instead of purchasing power and process steam separately, duPont buys metered heat as 1,200-lb. steam, delivered from the boiler room to the turbine allocated to its load. The duPont company purchases service through the billing of steam generation costs, proportional fixed and operating charges, etc., adjusted for equity.

Energy generated by the high-pressure turbine is transmitted to the duPont plant at the generator voltage of 11,000 through underground cables. The 11,000-volt duPont equipment is also tied into the power company buses through transformers, so that the load may always be adjusted to meet the process-steam demand. Steam admission to the turbine is controlled by vapor pres-

sure. The evaporators are one of the most interesting features of Deepwater station. They solve at one stroke the problem of high make-up generally associated with process-steam installations. There is still, of course, the problem of make-up to the evaporators, and their periodic cleaning, but this is relatively simple and involves no danger of tube failure.

To keep first cost within reason, evaporators must be built to operate with a substantial temperature difference. With 1,200-lb. steam at the turbine throttle, there is ample range for expansion through the high-pressure turbine, followed by the necessary temperature drop from turbine exhaust to process vapor.



Three of the seven process evaporators at Deepwater are shown in the foreground at the left of the duPont turbine. Beneath the turbine room floor are four more evaporators. Above are shown the process vapor lines running to the duPont plant

When receiving 530,000 lb. of exhaust steam per hour the battery of seven evaporators will produce 400,000 lb. of vapor per hour at 180 lb. pressure.

As an auxiliary steam supply to duPont, a reducing valve is installed in parallel with the turbine. Thus steam reduced directly from boiler pressure can be used in the evaporaters when the turbine is down for repairs.

Steam is carried to the duPont plant by two 16-in. process lines, while the returns are brought back by two 6-in. water lines. The latter join to supply a pump which forces the water first through the gland steam condenser, and then to the battery of evaporators.

It is arranged that the duPont company pay in monthly installments a sum representing a reasonable return on the investment in those plant facilities that are specifically allocated to its service. It pays also its proportionate share of all direct operating and maintenance costs, including fuel.

In return for these payments the duPont company is entitled to all electric power generated by the steam that passes through its high-pressure turbine unit. Provision is made for unbalance between duPont electrical and steam requirements. If the process steam load produces more than the required electrical power, the excess flows into the utility system and is credited to the duPont company. Conversely, an excess demand for electric power will be drawn from the utilities' power system.

ANOTHER interesting example of a case where the utility furnishes both process steam and byproduct power for industrial plants is found at Mobile, Ala. There the Southeastern Production Company has recently completed a central station to furnish power and process steam to the new paper mill of the International Paper Company, located about 700 ft. from the power-house. While the International Paper Company is at present the only customer for the steam output of this plant, others are expected in the near future.

The extraction turbine at Mobile does not *exhaust* to process. Steam is bled from the turbine at two pressures. Under normal conditions, however, this bleeding takes care of practically all of the steam supplied at the throttle, the amount of exhaust steam being sufficient

to take care of first-stage feed-water heating only. There is no condenser, so that this avenue for heat waste is eliminated. Under the circumstances the output of this machine is as truly byproduct power as if it came directly from a back-pressure turbine.

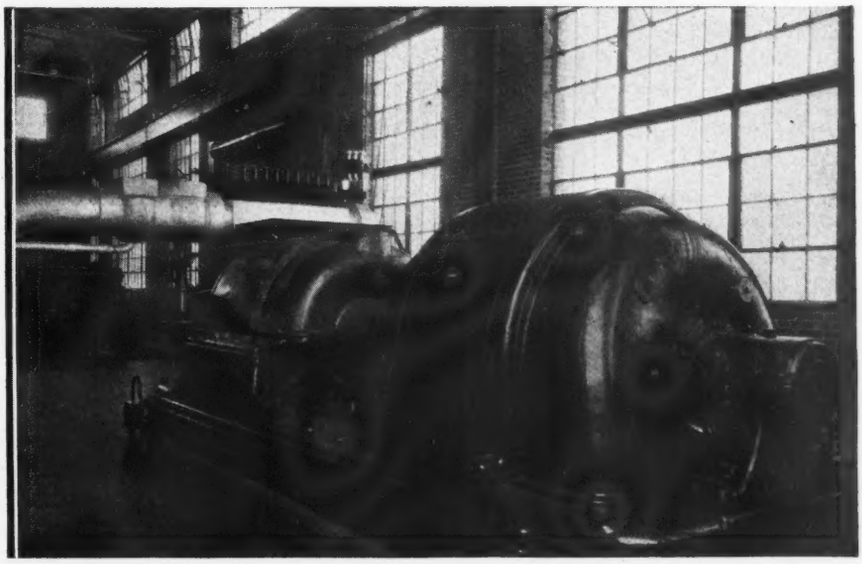
The process turbine is a double-extraction, non-condensing 6,000-kw. back-pressure unit supplied with throttle steam at 450 lb. gage and 650-deg. total temperature. Process steam is bled at 150 lb. and 35 lb. gage. The exhaust pressure is 5 lb.

This unit is designed to pass a maximum of 190,000 lb. of steam per hour between the throttle and the 150-lb. extraction point, where up to 100,000 lb. per hour may be withdrawn. Of this quantity, from 80,000 to 85,000 lb. per hour can be delivered as process steam to the paper mill for use in steam digesters, or for supplying steam turbines driving paper machines. This steam may be superheated not to exceed 100 deg. The remainder of the steam extracted at 150 lb. passes to the high-stage closed feed-water heater.

The steam supply at 150 lb. may, if desired, be reinforced by boiler steam passed through a desuperheater and a pressure-reducing valve. In like manner, the 150-lb. steam may be further desuperheated and its pressure reduced to 35 lb. to supply that line, if the supply of 35-lb. steam should be insufficient.

Process steam at the two pressures is carried 700 ft. to the plant of the International Paper Company by two steam lines, a 12-in. line for the 150-lb. steam and a 14-in. line for the 35-lb. steam.

As a stand-by power supply, an additional straight condensing turbine of 2,000-kw. capacity is provided. This is designed to operate with a jet condenser. The 6,000-kw. process-steam machine will run during normal operation, and the small machine will be held in reserve. Busbars into which these machines feed supply power to the paper mill and are also connected through transformers with the transmission system of the Alabama Power Company, which absorbs any surplus power. Of the process steam taken by the paper mill, only 35 to 45 per cent is expected to be returned as condensate. Makeup will be supplied from wells.



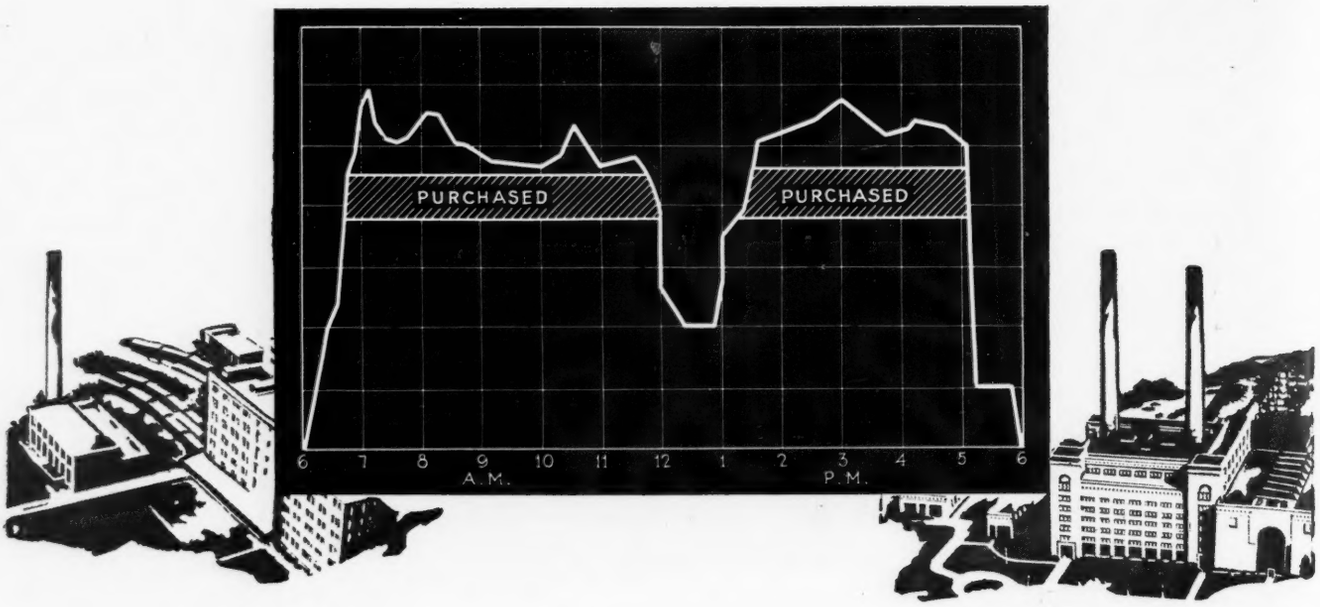
Steam for manufacturing is bled at two pressures from this turbine in the Mobile plant

The Mobile plant was designed by the Southeastern Engineering Company, and built by the Dixie Construction Company for the Southeastern Production Company. All are subsidiaries of the Southeastern Power & Light Company.

AT CEDAR RAPIDS, Iowa, a food plant furnishes to the utility part of the fuel energy later returned as steam and electricity. The Quaker Oats Company delivers oat hulls through 1,200 ft. of pipe to the local station of the Iowa Railway and Light Corporation, which in turn supplies steam and electricity to the Quaker Oats plant. Powdered coal is also burned in addition to the oat hulls as necessary to carry the load.

But, interesting as is this transfer of energy in the form of oat hulls, it is merely an incident in the general arrangement at Cedar Rapids. More significant are the contracts for steam and power. These contracts, laid out on a cost plus profit basis, involve a detailed system of cost allocation. They involve also the determination of standard unit costs, taking into consideration the ratio the consumer's load bears to that of the entire system.

Airplane view of Baton Rouge Station and the large Standard Oil of Louisiana refinery to which it supplies steam and power



When Should PART POWER Be PURCHASED?

Whether to install additional generating equipment or to purchase power is a question that must be decided as the load on the industrial power plant grows. A single fundamental equation is suggested to aid in this decision

POWER DEMANDS of a factory vary with the mill's production, and the management of a progressive industrial must at some point in the growth of the business face the problem of meeting an increased power demand. A correct answer to this problem is by no means easy to reach, and a poor decision now may load the factory with an excessive power charge for all time.

Where the factory has a power house, two methods of meeting increased demand can be considered; namely: purchase from the public utility, and generation in the mill's plant.

Frequently, when examining the relative merits of these methods, the error is made of assuming that unit cost of additional power, if generated in the industrial plant, would be the same as existing unit cost. This error may, and has, often caused a heavy monetary loss through the adoption of what seemed the cheaper, but what actually was the more expensive, plan of providing power.

In any plant the cost of generating power is made up of items which regardless of how they may be subdivided or allocated for accounting purposes fall under the following heads: Overhead (including fixed charges), labor, fuel, maintenance, and supplies. None of these items can be ignored when computing the cost of generating present power requirements, but it does not follow that all of these items enter into the cost of generating additional power. Because it is costing 2c. per kilowatt-hour at present, no management should assume that it will cost 2c. per kilowatt-hour to generate an additional block of power.

Take the simple case of a factory that needs no process steam but generates its power. Additional power is needed. Present costs are 3c. per kilowatt-hour, and the question is, Shall this additional power be generated or purchased?

If we plot the kilowatt load against the time duration of this load, a graph similar to Fig. 1 will be obtained. Additional load similarly plotted will give a total load graph as shown by the curve in Fig. 2, the cross-hatched area being added load.

Now present cost of power, as has been pointed out, is made up of fixed charges, labor, fuel, maintenance, and supplies. Generation of an additional amount of

power by the present plant will not alter the total labor costs appreciably, if at all; nor will maintenance and supply items be altered greatly, save in an exceptional case to be mentioned later. Consequently, cost of additional power generation, even if a new unit must be installed, is made up of two items: Additional overhead O, and additional fuel expenditure F.

Cost of purchased energy is usually made up of a demand charge D, and an energy charge R, although in some instances the rate schedule may be considerably more involved.

With the several factors known, relative costs of generated and purchased power can be found, and the load beyond which it is cheaper to buy or generate can be ascertained with some precision, through the use of Fig. 3, which shows the same load conditions as Fig. 2. The base is the number of hours per year during which the kilowatt load was that shown by the vertical scale. Suppose the load has a value of X, and the cost of the additional increment dkw is to be found. The increment dkw has, as the graph shows, a duration of h hours per year. Total kilowatt-hour load of the increment is then $dkw \times h$.

The cost of this block, if generated in the factory plant, is made up of overhead O and fuel F, making the total cost $dkw \times O + dkw \times h \times F$, where O is the overhead charges per year per kilowatt of the added generating equipment, and F is the fuel cost per kilowatt-hour.

If this power be purchased, the energy will cost $dkw \times h \times R + dkw \times D$, where R is the energy charge per kilowatt-hour, and D is the charge per kilowatt of demand.

If the cost of generating dkw kilowatts for h hours is to equal that of $dkw \times h$ of purchased power, the two expressions become equal and may be expressed by the equation

$$dkw \times O + dkw \times h \times F = dkw \times h \times R + dkw \times D,$$

which may be reduced to

$$O + hF = hR + D, \text{ and}$$

$$h = \frac{O - D}{R - F}$$

If after inserting the several values, both the numerator and denominator are positive, the energy demand up to h should be purchased, this is indicated by the shaded area in Fig. 4.

For example, suppose it is found that an addition to an existing plant would cost $100 per kilowatt of capacity, and that an overhead of 13 per cent seems reasonable, making O equal to 13,000 mills. Also, the coal rate has been found to be 4 lb. per kilowatt-hour, which at $4 per ton makes the coal charge F equal to 8 mills. The demand charge for purchased energy would be $1 per month per kilowatt of maximum demand. This would make D equal to 12,000 mills per year. The energy charge works out as 1¼c. per kilowatt-hour, or $R = 12.5$ mills. Using the formula

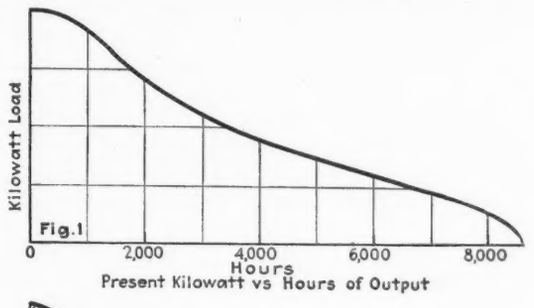
$$h = \frac{O - D}{R - F} = \frac{13{,}000 - 12{,}000}{12.5 - 8},$$

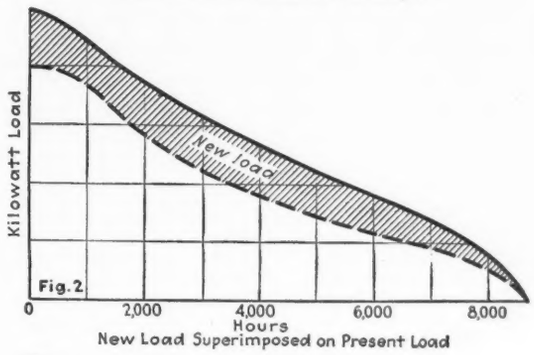
or,

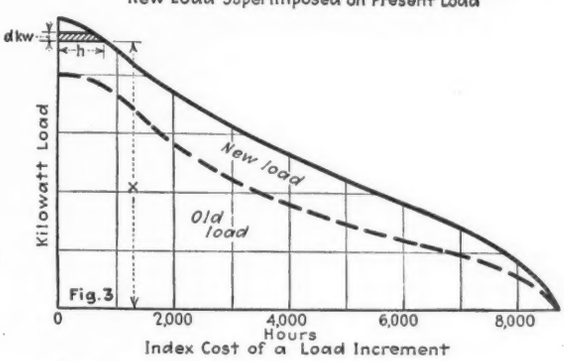
$$h = \frac{1{,}000}{4.5} = 222.$$

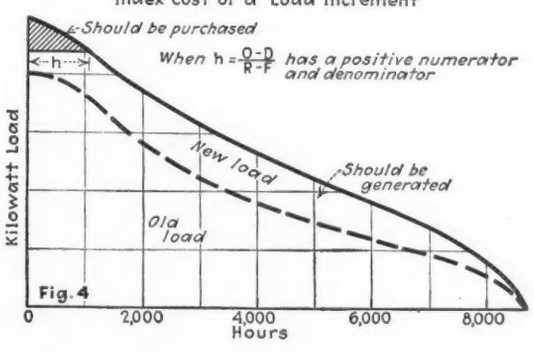
Evidently, energy used up to 222 hr. should be purchased and the balance generated.

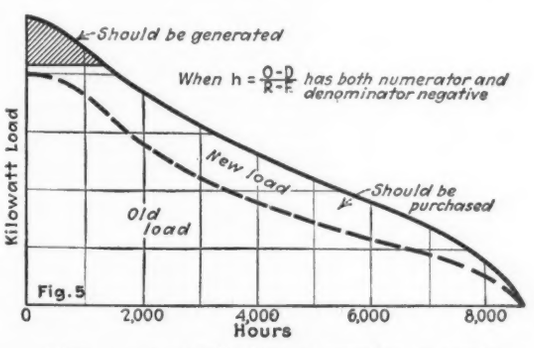
If both numerator and denominator are negative, power should be generated up to h hours, and the











Figs. 1 to 5—Application of equation to yearly load-duration curve

remainder of the load created by the extra factory demand should be met by purchase from the outside, as shown in Fig. 5.

Using the previous example, inspection of the equation reveals that, if the demand charge is higher than the overhead and the fuel charge is higher than the energy charge, the numerator becomes of less significance as the amount of energy increases, and at the same time the effect of the differential between fuel and energy charges becomes increasingly important. It would then pay to carry the h hour peak by the plant's own new equipment, and buy the remaining excess new demand. This, in effect, reduces the demand charge, which frequently is determined for twelve months by a fifteen- or thirty-minute peak load.

On the other hand, if the numerator is negative and the denominator is positive the plant should generate all the power; but with a negative denominator and a positive numerator all excess power should be purchased and the existing plant used without increase in new equipment.

Obviously, if the overhead is greater than the demand charges, and the fuel is greater than the energy rate, there is nothing favoring the generation of the excess power, and it should be purchased.

Calculations are based upon the stipulation that the demand charge is uniform, and that the energy charge R is uniform. If the block system is used, computations should be repeated using the rate applying to the particular block of power in which the energy consumption would fall.

Of course, the resulting decision is greatly influenced by the accuracy with which the fuel charged for the increment kilowatt load is estimated. In addition to considering the improved efficiency of modern power generating equipment and the probable loading at which it will operate, attention should be given to the possibility of generating power as a byproduct of process steam. Thus it may be necessary also to determine the increase in process steam requirements that may be expected as the industry grows. If a plant has capacity

to meet the additional load, the purchase of this increment is justified only where the public utility is able to offer power at an extremely low energy and demand charge, or on a flat yearly basis. If an industrial finds that its coal rate is greater than the purchased-power energy charge, the assumption is that the plant is either equipped with obsolete machinery or the machines are indifferently operated and maintained.

Frequently an operating force may declare that existing equipment is incapable of carrying an additional load. If the generating units are turbines, one should not expect them to carry much more than their nameplate rating. Consequently, an additional turbine might have to be purchased. On the other hand, if reciprocating engines are used, a greater load might be carried because of the inherent overload capacity of this type of machine. This is especially true where new peak load over engine rating does not extend over three or four hours. Consideration, however, must be given to possible increase in steam rate by reason of additional load, also the generator rating.

Present boiler capacity may be ample. This is especially true where the operating force customarily runs the boilers at their nominal rating or less. Industrial plants, in general, have not accepted high-output firing methods that characterize the operation of public utility boiler rooms.

If boilers are hand-fired, it is difficult to persuade the firemen to push the output beyond this figure. But in stoker-fired or pulverized-coal plants ratings up to 250

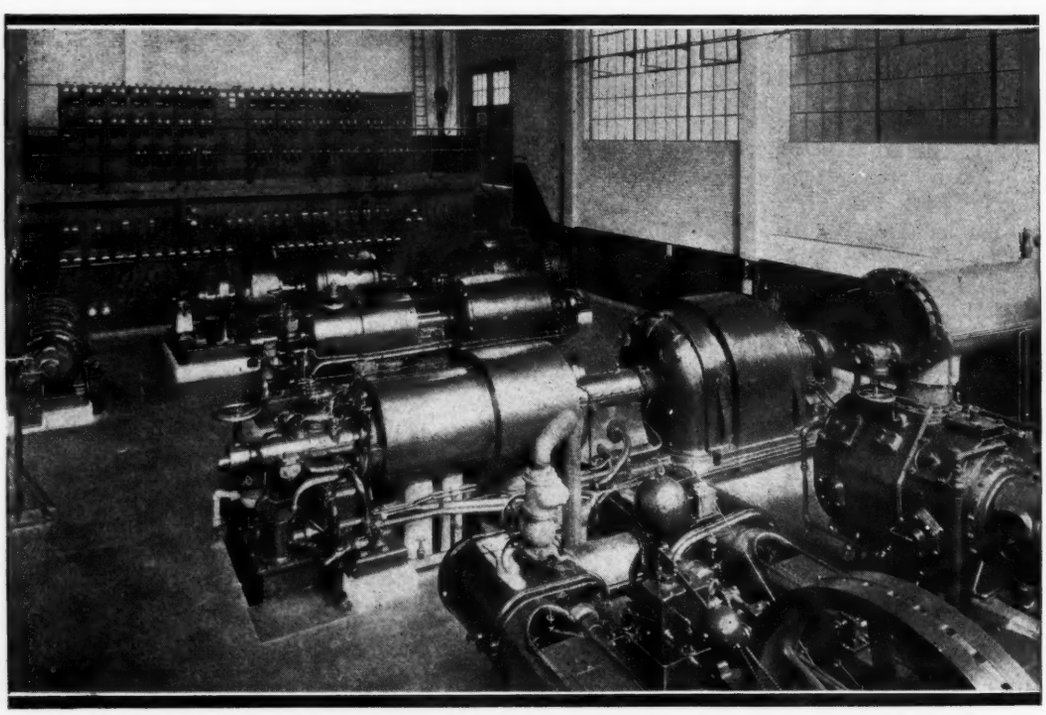


Fig. 6 — Otis Elevator Company decided that purchased energy should be used to meet the excess power requirements at its Yonkers plant

per cent may be feasible with ordinary refractory walls.

Furthermore, it is not unusual to encounter operating pressures of 150 lb. when the boilers were designed for 200 lb. If the generating units will safely handle the higher pressure, present boiler capacity may not need an addition. The matter of spare boilers deserves examination in such a power study. Where an industrial is operating 5½ days a week with one eight-hour shift, the economy of having a stand-by boiler is open to question. Outside of a rupture, which would probably entail a complete plant shutdown, ordinary boiler repairs can be made during the week-end or even between shifts. Usually in time of distress the factory can temporarily reduce its load demand without affecting the week's output of manufactured articles.

It will be noticed that the formula given declares that if the overhead is less than the demand, and the fuel charge is greater than the energy charge, the factory should generate all the power increment up to h hours, and buy the base demand.

If study reveals that for economic or other reasons it is desirable to purchase power, a close examination should be made of rate schedule. Frequently a schedule exists which if taken advantage of will lead to savings compared to a more-used standard rate.

Some utilities have a charge of, say, $1 per month per kilowatt of maximum demand, based on the highest 15 min. peak load. This single peak may be used to establish the demand charge for the entire year. But at times it is possible to obtain a monthly demand, which, if the factory has an off season, may reduce total power costs to a marked degree.

Other utilities set up special demand plans for such seasonal plants as irrigation, cotton gins, and oil mills. With these the demand charge applies only during the actual season of energy consumption. It is well to examine all possible schedules offered by a utility.

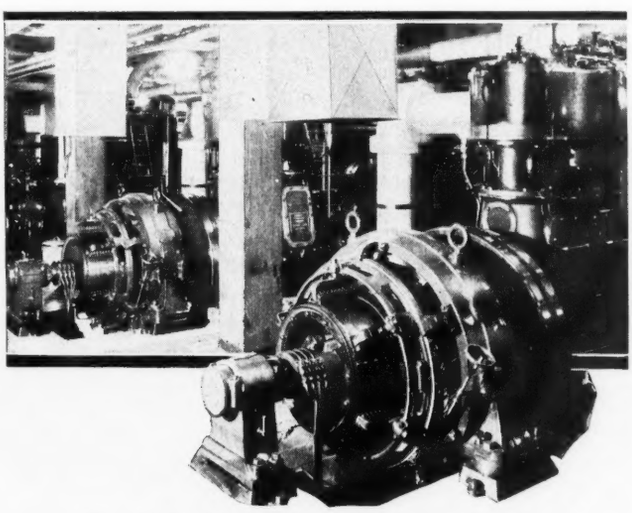


Fig. 8—The Royal York Hotel generates direct current from process steam and purchases alternating-current to meet the remainder of its needs

On certain utility systems, especially when a street car load is carried, the system's peak demand occurs between 5 and 7 p.m. At times a low rate is offered to factories that will discontinue their electrical consumption during these hours. To take advantage of the low rate an industrial might well afford to change its hours of operation. If the utility's morning load has a peak that precludes the factory's shifting its working hours forward to avoid the evening peak, savings in power might justify establishment of a seven- or even a six-hour day—equalizing the output by speeding up methods or by a second shift.

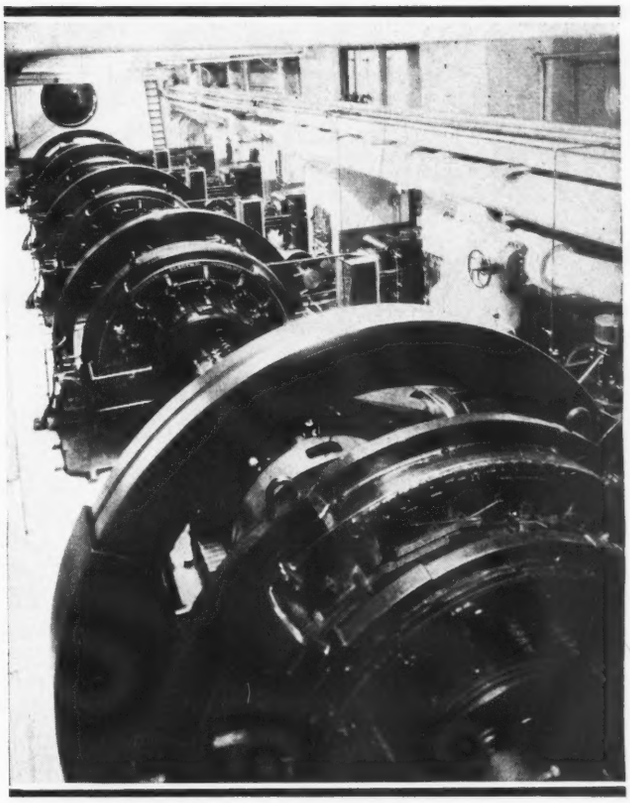


Fig. 7—With increased demand, and the impossibility of installing more boilers, R. H. Macy Company provided two 800-kw. Diesel engines

While industry in general tends to adopt the one-shift method of operation, at times two shifts or three shifts will lead to such savings in power costs that even if a part be used as wage incentive for the night shift a substantial margin of profit exists to justify a two-shift plan. In fact, many workmen prefer a night shift.

In at least one instance, an industrial closed one of its plants and operated a second mill on a three-shift plan to obtain a low power cost.

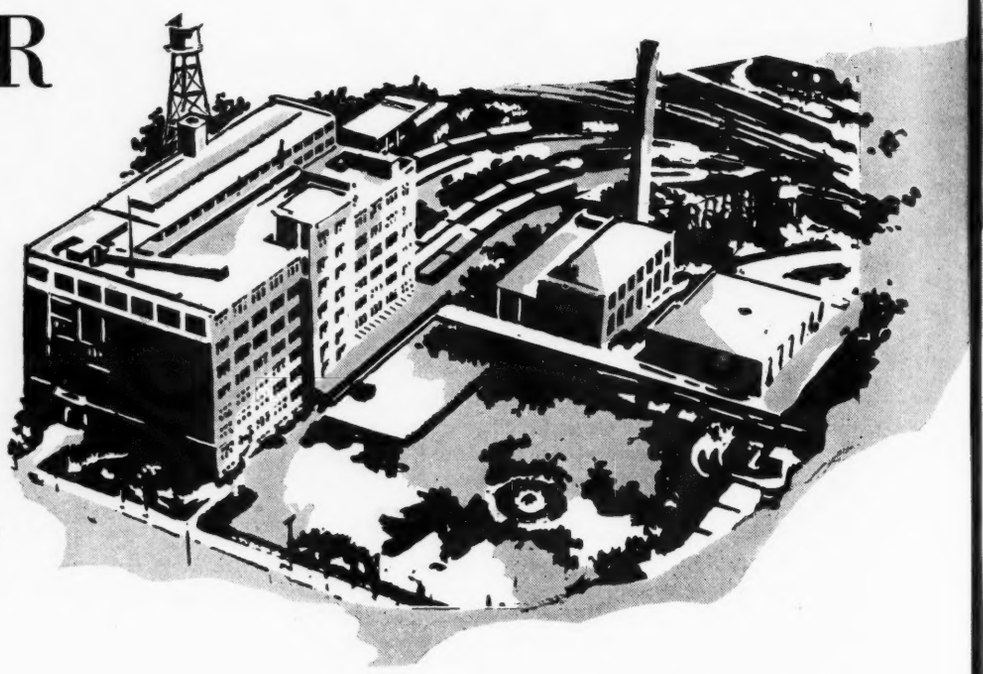
If purchased energy works out as the better power source, attention should be given to operating procedure. With a factory power house operating in parallel with utility lines, the utility usually so arranges the meter that if power is fed back into the transmission lines it does not affect the meter's reading. Consequently, the turbine room operator must be cautioned to use due diligence never to generate more power than the mill is taking.

To prevent sudden peaks from increasing the demand, and, consequently, the cost of power, it may be advisable to run the mill's power plant under its capacity so that it can absorb sudden peaks in demand.

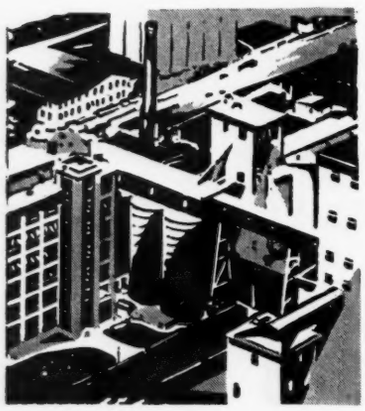
Because the solution of the problem has been reduced to a single equation, it should not be assumed that it is a simple one. Several of the factors are difficult to determine and require experienced judgment to estimate. They are affected by local conditions peculiar to each plant considered, and each case must be judged on its own merits. It would be wrong to assume that purchased power is economical only because a neighboring plant decided to buy peak energy.

WHERE INDUSTRIAL PLANTS GAIN BY EXCHANGE OF POWER

SOME of the conditions that make the exchange of power between utility and industrial power plants a mutually profitable venture are indicated by existing illustrations of such relations.



WITHIN the past five years there has been a marked increase in the amount of power generated as a byproduct of process steam. This has been due to the general acceptance of higher pressures, which makes it possible to obtain a greater number of kilowatts from a pound of process steam. In addition, waste heat and waste fuel are being utilized to a greater extent for power generation, and the development of small hydro plants has continued. In many cases the electric energy obtainable from these sources is in excess of that required by the industry with which it is associated. Industry has frequently been able to dispose of this excess cheap power by selling it to the utility. During 1929 the United States Census Bureau reports the sale by industrial plants of 538,747,000 kw.-hr. to utility power systems. Although this figure has been found to be incomplete, it nevertheless represents about one-half of 1 per cent of the total energy generated by utility plants. It is a significant figure, considering that this current is generated by concerns not in the business of manufacturing power, and that it represents conservation of prime energy sources.

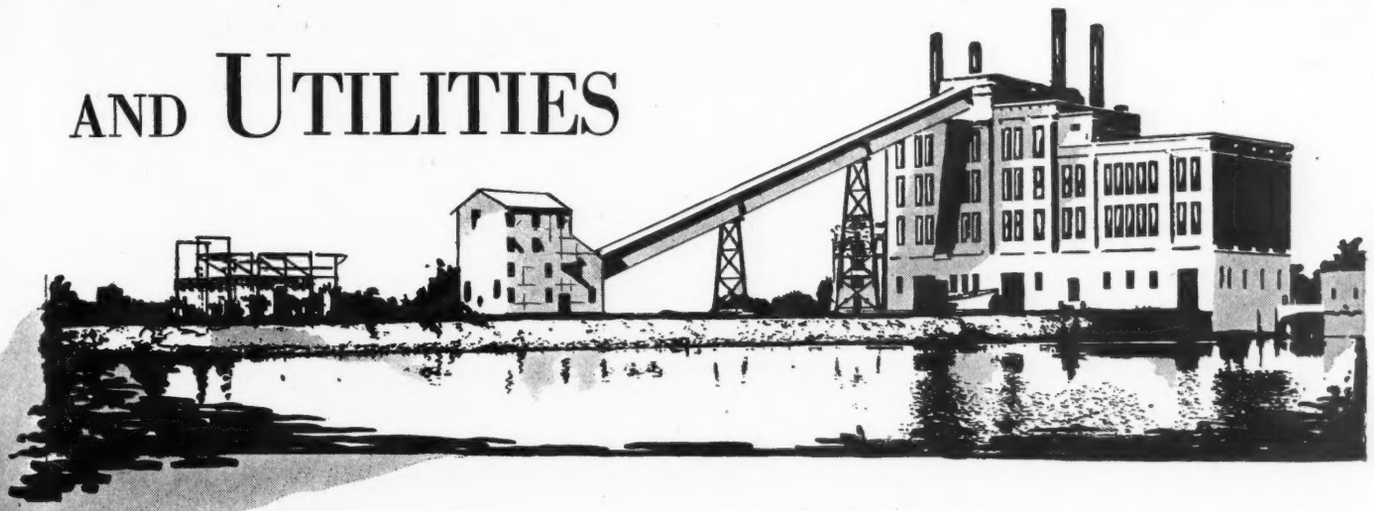


This sale of power to the utility is the result of a definite economic situation that permits industry to generate additional kilowatts more cheaply than the utility. Obviously, the utility cannot afford to purchase power unless it benefits thereby, and the industrial plant cannot reasonably sell its excess power at less than cost. As old industrial plants are modernized by the installation of higher-pressure equipment it may be expected that the utilities will be able to profit by the purchase of still greater quantities of cheap power.

There are at least five situations or conditions under which an industrial plant can exchange or sell power to the utility at rates profitable to both parties. These conditions are:

1. Where a hydro development yields power in excess of manufacturing demands.
2. Where waste heat or waste fuel is available for producing more power than the industry requires.
3. Where oil-engine power is available for sale during utility peak load.
4. Where the demand for process steam permits the generation of byproduct power in excess of that needed by the manufacturing operation, or where the demands for process steam and power do not coincide.

AND UTILITIES



Before giving examples of plants operating under these conditions it will be advisable to point out the advantages that accrue to both the private plant and utility, and to discuss some of the factors that the utility examines before the purchase of power can be considered.

The obvious advantage to the private plant is the revenue obtained from the sale of excess power. In addition, operation in parallel with the utility generally will result in better speed and voltage regulation for the industrial, which in some cases, such as in textile and paper plants, is of considerable importance. Connection with the utility also provides stand-by capacity, which service can be capitalized by reduction of reserve capacity in the private plant.

Except under unusual circumstances the utility cannot afford to purchase energy unless available at a rate less than its own increment generating cost. If this were the only thing to be considered, it would appear that the utility should purchase all such cheap power offered. There are, however, other factors that must be considered. These involve the time at which the power is available, and quantity and dependability of the power offered. It would not be reasonable to expect a utility to purchase power during its own low-load period, but, on the other hand, power offered during its peak load would generally be quite welcome. If the power from the private plant is dependable and firm in character, such as may be the case when it is obtained from a hydro development, the utility may be able to consider this capacity as part of its own and so reduce the reserve capacity installed in its plants.

Frequently it happens that the industrial plant is located near the end of a long transmission line. The power house of such a plant, when operating in parallel with the utility system, may become very useful as a voltage stabilizer. In some instances a private plant so situated has been of great assistance to the utility during temporary trouble on the transmission lines, when it has supplied energy to the immediate neighborhood.

Excess power from industrial hydro-electric plants generally is of steadier character and less subject to fluctuations than is the excess byproduct power available from a plant generating power from process steam or using waste heat. For this reason it is more attractive for the utility to contract for power from this source. In addition, the special conditions that make possible the sale of steam power at rates below the utility's generating cost are not required in the case of hydro power. In case the industrial develops a hydro site and installs generating equipment in excess of its own normal reserve capacity, the revenue from the sale of excess power must be sufficient to yield a return on the investment in excess capacity. If, however, the energy sold is developed from equipment that would have been installed ordinarily as spare capacity, fixed charges do not have to be considered, and any revenue received from sale to the utility is net profit.

An illustration of the first case is found in the power developments of the Northern Paper Mills at Green Bay, Wis. This mill had a plant designed to produce power from process steam requirements. In it were installed reciprocating engines exhausting to driers, and a 2,000-kw. extraction turbine. The power produced from process steam did not meet the total requirements, and about 13,600,000 kw.-hr. a year was purchased.

A hydro site was available on the Menominee River, about 83 miles from the paper mills. Its most economical development dictated the construction of two plants of about equal capacity operating on heads of 28 and 29 ft. Together these plants would develop about twice the additional power required for manufacturing, so it was at first decided to build only one plant and reserve the second for a future development.

Construction of both plants at the same time could be accomplished at considerably less cost, and was desirable providing some use could be made of the power developed. Consequently, prior to construction, negotiations were concluded for the sale of power from one of these plants to the Wisconsin-Michigan Power Company. The terms of the sale agreement are that the utility is to take all of the power that can be produced from the Chalk Hill plant using river run.

This plant is about 2½ miles above the White Rapids plant. It contains three vertical turbines each driving 3,250-kva. generators operating at 150 r.p.m. At the White Rapids plant two vertical turbines drive 3,750-kva. generators, and a third wheel drives a 2,500-kva. unit.

Power is generated at 2,300 volts and stepped up to 132,000 volts in an outside transformer substation, from where it is sent 83 miles over a steel tower transmission line to the paper mills. The utility has leased one-half of the cross-arm space of the transmission line for a period of fifty years. As a two-circuit tower line is only slightly more costly than a one-circuit line both the Northern Paper Mills and the utility have benefited. Be-

cause of its contract with the public utility the paper mill has been able to build both hydro plants at less first cost than would have been possible had they been built separately. The contract for sale of the output of one of the plants was a definite asset in financing the project. And in addition revenue is obtained from the sale of power and from the transmission line lease.

The utility profits because of the source of cheap power and because of its use of the transmission line, which forms part of a link connecting the utility's plants at Iron Mountain with the Milwaukee pool of power.

Two nearly identical plants that serve to operate the Erie Canal near Cohoes, N. Y., are further cases of the sale of energy from excess generating equipment. Both plants have a rated output of about 5,600 kw., and at each 250 kw. of capacity are held in reserve for canal operation. During the year each plant sold about 3,500,000 kw.-hr. to the utility.

The terms of the contract with the utility establishes a two-part rate consisting of a low rate per kilowatt-hour and a capacity charge, which varies from month to month depending upon the amount of water available. There is a minimum sum which the utility must pay regardless of the amount of energy it may take from the state plants. This minimum pays the investment charges and operating cost of additional equipment.

An example of an industrial plant that is required to develop the full power of the river and dispose of all surplus to a public utility is the Twin City plant of the Ford Motor Company. The plant is on the St. Paul side of the Mississippi River, about seven miles southeast of the business center of Minneapolis. This arrangement was made with the government some eight years ago when the Ford Motor Company was considering the erection of the assembly and glass-making plant that is now in operation there.

For a number of years previous the government had been building control works at the headwaters of the Mississippi River and a dam and locks at the site under discussion to maintain the river level for navigation. It was the intention also to build a power plant that would utilize the 34-foot drop of the river at this point. At this time the Ford offer was accepted, with provision that the full power of the river be developed, except at flood periods, and that the surplus over Ford needs and the amount of power required by the government to operate the locks be utilized. Arrangements with the Northern States Power Company to take the entire surplus at an equitable rate assured complete utilization, so construction work began, and the new Ford plant was ready for service late in 1924.

It was decided to install four 4,500-hp. vertical Francis type wheels which, under a head of 34 ft. and at a speed of 100 r.p.m., drive four 4,500-kva., 13,800-volt generators. As many of these machines as are necessary to use the full flow of the river are maintained in operation.

That the river level may be maintained nearly constant the government established reservoirs and control works at the headwaters. During the past four years the amount of water in storage has varied from an average of 13,137,000 to 48,383,000 cu.ft. Because of this variation two 5,000-kw. turbine-generators arranged to operate condensing were installed in the steam plant located a few hundred feet down the river. They were provided as a factor of safety against insufficient power for full operation, but up to the present there has been no occasion to operate either machine.

The exact amounts generated in the past four years are given in the table. Ford requirements range from

GENERATION AND DISTRIBUTION OF WATER POWER AT THE FORD TWIN CITY PLANT

Year	Total Power Gen., Kw.-Hr.	Service to Hydro Station Aux., Kw.-Hr.	Power to Government for Op. of Locks, Kw.-Hr.	Power to Utility, Kw.-Hr.	Power to Ford Motor Company, Kw.-Hr.
1926	56,816,000	273,600	25,944	43,743,000	12,773,000
1927	78,081,000	254,765	30,099	69,096,000	8,700,136
1928	84,759,000	232,926	27,319	73,421,000	11,077 755
1929	71,564,000	242,656	89,530	56,173,000	15,058,814

8,700,136 to 15,058,814 kw.-hr. per year, and the surplus sold to the utility varies from 43,743,000 to 73,421,000 kw.-hr.

By an investment of approximately $1,500,000, or $104 per kilowatt of capacity, in the water-power plant, the Ford company is assured of its own power requirements, the government is assured of free power for lock operation, and in addition there is a considerable income from the surplus.

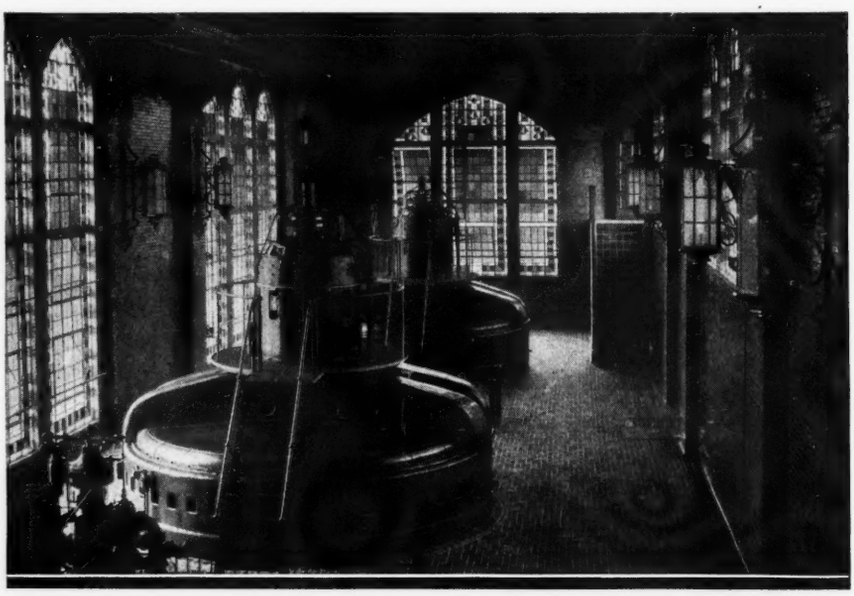


Fig. 1—Interior of Chalk Hill power house of the Northern Paper Mills

An illustration of the sale of excess power from a hydro plant developed only to meet the needs of the industrial is found at the plant of the Newton Falls Paper Company. The hydro plant which this company developed has a maximum capacity of 1,800 kw. The power required by the mills amounts to about 1,500 kw., leaving as spare about 300 kilowatts.

Connection has been made to the lines of the Northern New York Utilities, which stands ready to provide power when needed during low water or emergency. The utility has also contracted to purchase all excess power that may be developed at the plant during high-water periods. This excess it has agreed to take at any time, including nights, Sundays, and holidays. During the year ending March 31, 1930, the utility purchased 1,291,-

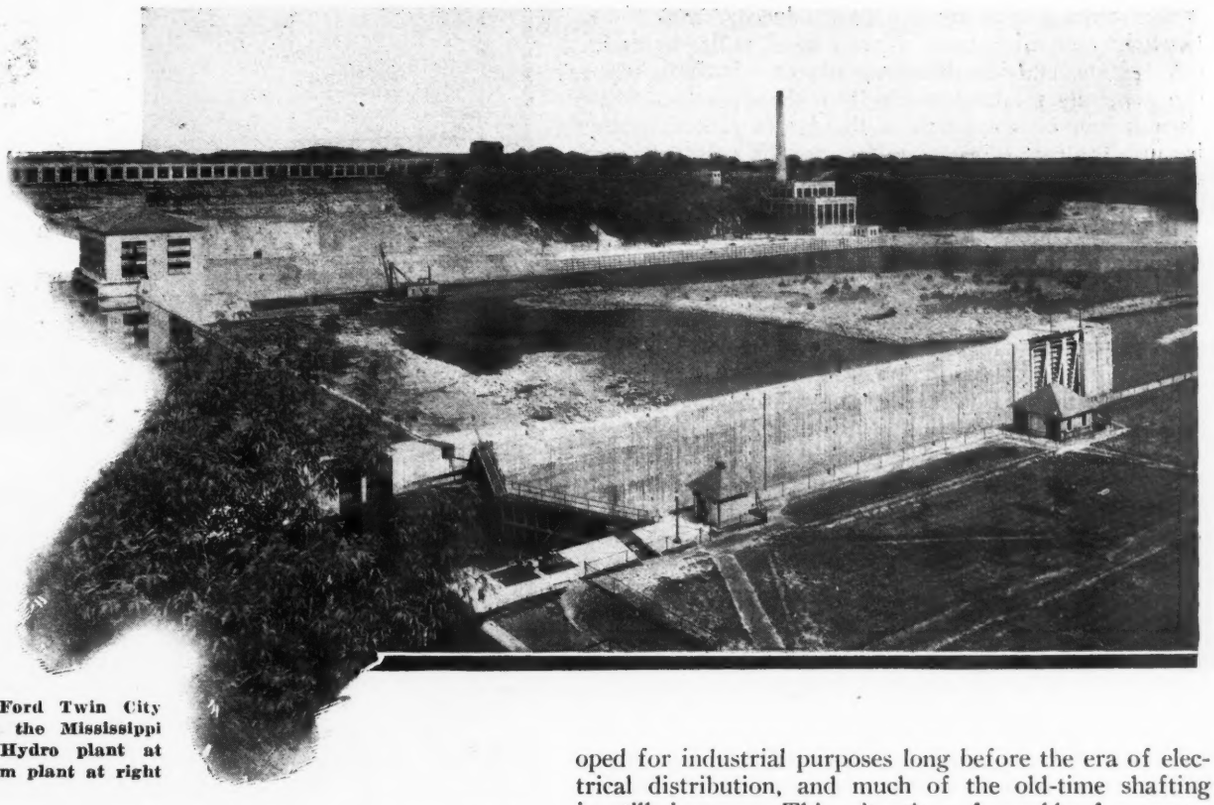


Fig. 2—Ford Twin City plant on the Mississippi River. Hydro plant at left, steam plant at right

500 kw.-hr. and sold to the paper company 521,500 kilowatt-hours.

The Northern New York Utilities has several hydro plants in its system. Assuming water is available at these plants, the increment cost of a kilowatt to the utility is so extremely small that it would be impossible to buy power at a profit. However, at these hydro plants the utility has considerable water storage, so that power purchased from the paper company makes possible the storage of corresponding amounts of water that can be used to supply energy during the utility's peak. Furthermore, the paper company can afford to sell its excess power at a very low rate, since no investment overhead can properly be charged against its production, and

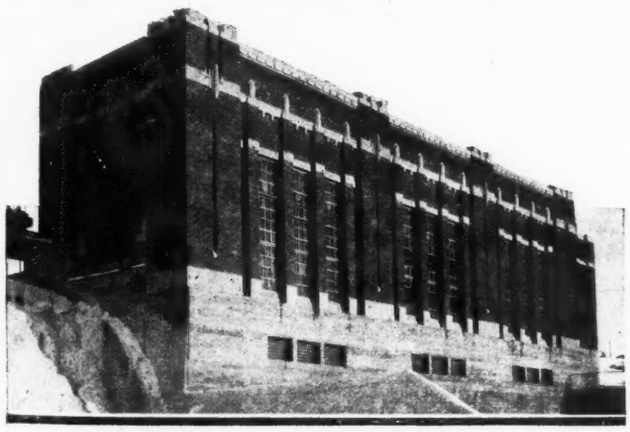


Fig. 3—White Rapids plant of Northern Paper Mills

because, it being a hydro plant, there is no charge for fuel.

In New England, America's oldest industrial section, historic factors long ago created special conditions that today open new possibilities for utilities and industrial plants to interchange power with mutual profit. Much of the potential water power of New England was developed for industrial purposes long before the era of electrical distribution, and much of the old-time shafting is still in use. This situation, favorable for power exchange with utilities, has already received recognition.

A case at hand is that of the Wauregan Mills[1] situated on the Quinebaug River at Wauregan, Conn. Cotton is spun and woven in this plant, which does no finishing and, therefore, has virtually no demand for steam, except for building heating in winter.

Formerly this plant ran on its own water power reinforced by a 1,200-hp. condensing engine during periods of low water. Three waterwheels and the engine were belted to a line shaft driving a 625-kva. generator, and two wheels were belted to another shaft.

When the available water power fell slightly below the mill demand it was necessary to operate the engine at a low, and uneconomical, load. The mill ran 54 hr. weekly, leaving 114 hr. during which much water was wasted over the dam because of low storage capacity.

About a year ago arrangements for power exchange were made with the Eastern Connecticut Power Company. One pair of waterwheels was disconnected from the line shaft and belted to a new 500-kva. generator. The arrangement with the power company provided for the purchase of power up to 300 kw. by the mill and for the sale to the utility of surplus power up to 1,000 kw.

In normal operation during seasons of ample water supply the mill runs on water power only. As the dry season approaches and the hydro capacity falls slightly below the mill demand excess requirements are purchased to avoid operating the engine at an uneconomical load. When, however, the purchased load reaches 300 kw. or thereabout, it becomes economical to start the engine and shut off the purchased power. If, finally, further falling off of water power causes the load to exceed the combined hydro and steam capacity, the excess is again necessarily purchased. During non-working hours all available water power is sold to the utility.

Many industries have waste heat or waste fuel from

[1]Information through courtesy of Warren Lewis, consulting engineer, Providence.

which steam and power can be produced. This is particularly true of cement plants, steel mills, byproduct coke plants, and woodworking plants. Such industries can generally produce power from these wastes cheaper than it can be produced in the steam central station, because the cost of fuel can be charged only at what it would bring if sold. In the case of waste heat and wood refuse the fuel cost is negligible.

Sometimes more electric energy can be produced from these wastes than the industry requires for its own power needs. Such excess power, because of its low cost, can be sold to the utility at a rate below the utility's increment generating cost and still yield a profit to the industrial. When these conditions exist the sale of industrial power benefits both utility and industrial and at the same time conserves natural fuel resources.

The cement plant affords an excellent opportunity for power exchange with utilities. Of the heat in the coal used to fire the cement kilns about 45 per cent is rejected and is available for producing steam. The power production based on coal burned in the kilns will vary from 3.5 to 5.5 lb. of coal per kilowatt-hour, or about 600 lb. of steam can be produced per barrel of cement.

In 1928 the North American Cement Corporation revamped its Security, Md., plant so that the waste heat from its kilns could be efficiently utilized for generating power. With all five kilns in operation more power is generated than is required to operate the entire plant. Arrangements have been made to sell excess power in amounts not exceeding 1,000 kw. to the Potomac Edison Company. The power company has agreed to take this excess at any time, but pays only half as much for night power as it does for that taken during the day.

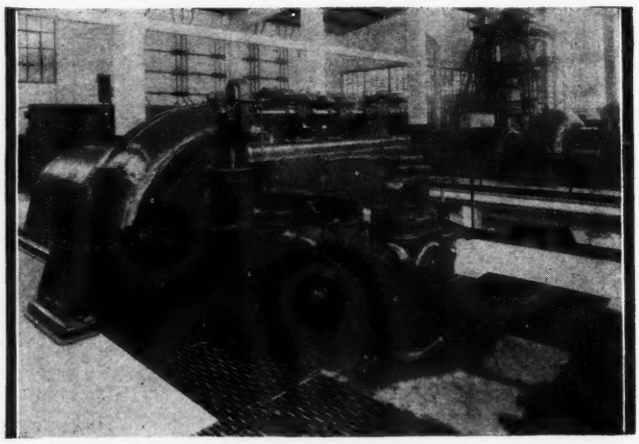
The power house contains three 10,060-sq.ft. waste-heat boilers equipped with superheaters and economizers. Steam is generated at about 200 lb. and superheated to 150 deg. F.

No auxiliary coal-burning equipment has been installed under the boilers. The plant is thus entirely dependent upon waste heat for generating power, and in case the kilns are shut down power must be purchased for starting up. During the year 43,500 kw.-hr. was purchased for this purpose.

Two condensing turbines each drive 3,750-kva. generators. Since these units operate in parallel with the utility, their speed is governed by the frequency on the utility's system.

Operation of a plant of this character is quite different from that in the normal isolated plant. The output of the boilers is determined solely by the waste heat delivered to them by the cement kilns; therefore the boiler room has no control over the steam pressure. The turbines instead of being operated to serve a definite load must be regulated to use just the amount of steam produced by the boiler, otherwise the steam pressure will fluctuate with variations in kiln operation. Thus the turbine load would be controlled according to pressure gage indications instead of frequency or watt-meter readings.

During 1929 a total of 35,015,000 kw.-hr. was generated by these turbines. Of this, 9,856,600 kw.-hr., or about 28 per cent of the total output, was sold to the utility.



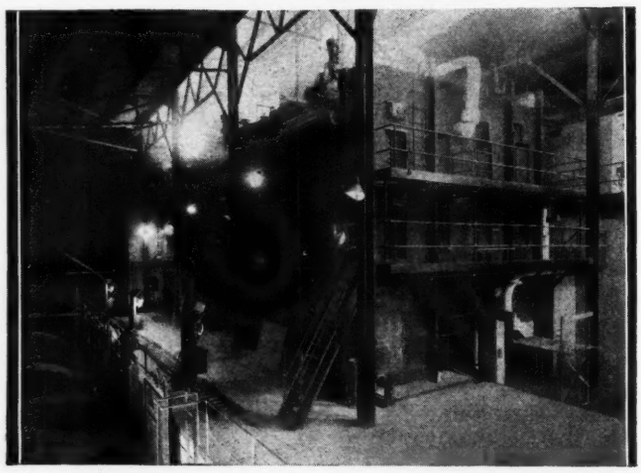


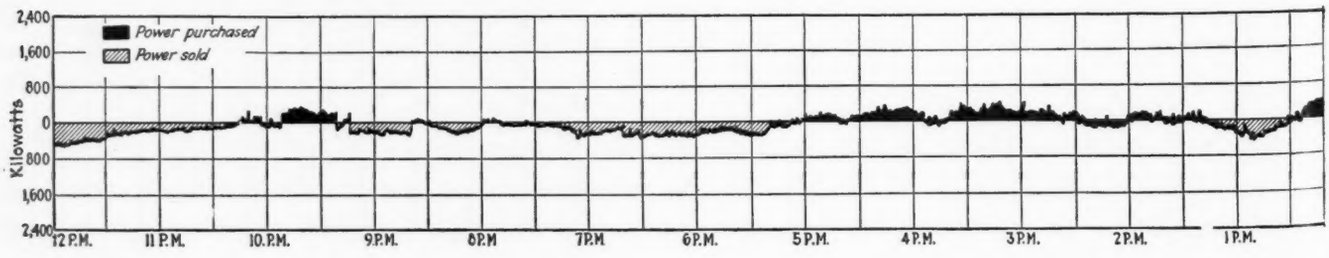
Fig. 4—Turbine room and waste heat boilers at the Security plant of the North American Cement Corporation

The net result of the exchange of power has been that the revenue from the power sold has slightly more than paid for the energy purchased and the cost of utility stand-by service. It might be said that the utility has exchanged stand-by service for a considerable block of energy.

At Boettcher, seven miles south of Fort Collins, Colo., the Colorado Portland Cement Company recently built a new plant of 3,500-bbl. capacity. Waste-heat boilers deliver steam to a 5,000-kw. turbine operated in parallel with the public service company.

An average of 3,612 kw. is required for producing cement. Average production of power from waste heat is 4,400 kw. The surplus is sold to the utility. The plant is connected to the utility system through 1,000-kva.

Fig. 6—Curve showing hourly exchange of power between Michigan University and the Detroit Edison Company.



transformers, which limit the sale of power to amounts not exceeding the capacity of the transformers.

Between the Manitowoc plant of the Medusa Portland Cement Company and the Wisconsin Public Service Company, which has a local station some two blocks distant, an arrangement has been made for the continuous interchange of power that has resulted in direct advantage to both parties and for the six years since its inception has given mutual satisfaction. The cement company generates all of the power that is available from steam made in waste-heat boilers that utilize the hot gas from three cement kilns. No direct-fired boiler was installed, and there is only one generating unit, which is operated continuously 24 hr. a day.

Rather than install reserve equipment for steam and electric generation, it was preferred to hold down the initial investment and enter into a contract with the utility that would make available energy for starting up or for the periods during which the main unit might be shut down. The contract made it possible to generate all the electrical energy that it was feasible to obtain from the waste heat, and at any time deliver the surplus to the utility.

The mill is equipped with three rotary kilns to produce approximately 4,000 bbl. of cement in 24 hr. The kilns are fired with pulverized coal, prepared in a separate building by three 42-in. mills. Each of the three kilns discharges its gas into a vertical, three-pass, six-drum 180-lb. pressure waste-heat boiler.

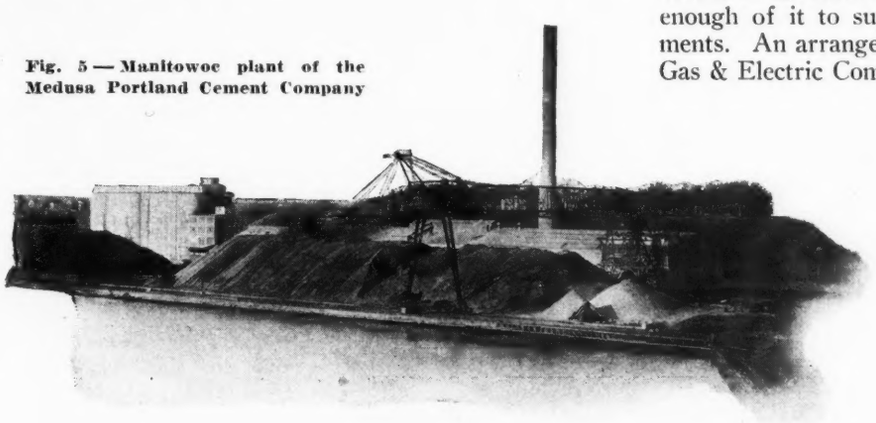


Fig. 5 — Manitowoc plant of the Medusa Portland Cement Company

The kilns and boilers operate continuously, the three of them generating on the average 1,500,000 lb. of steam in 24 hr. The bulk of this, roughly 1,165,000 lb., goes to the one turbine unit comprising the generating plant of the mill. This is a 3,125-kva., 2,300-volt, 60-cycle generator driven at 3,600 r.p.m. by a turbine operating condensing. On the three-kiln basis the output runs from 62,000 to 75,000 kw.-hr. per 24-hr. day, the output for the month of January this year totaling 1,810,000 kw.-hr. Of this total, 1,557,200 kw.-hr. was used in the mill. Most of the balance was sold to the utility, and a relatively small amount was purchased.

Summarizing the advantages of this interconnection, both parties to the contract are benefited, in that one plant or system acts as a reserve for the other, eliminating the need for reserve equipment in the cement plant. Upon occasion the utility has been helped in a difficult situation by the cement plant, and, on the other hand, the utility actually supplies breakdown service to the mill. The cement plant is able to utilize to the full its waste heat. No steam is blown to atmosphere, and any shortage of current at any time is met by the power company. Its fuel cost for power generation is zero, and additional profit is netted on the power sold.

The utility is benefited by a cheap, although irregular, supply of power. The power factor of the utility system is benefited by the mill connection. A reserve in case of need is available, and a profit is obtained on the energy sold to the mill at standard rates.

Utilization of waste fuel for power generation falls under much the same heading as power produced from waste heat, although the plant equipment is different. In both cases the cost of fuel is not chargeable to the cost of power, which is, therefore, produced very cheaply.

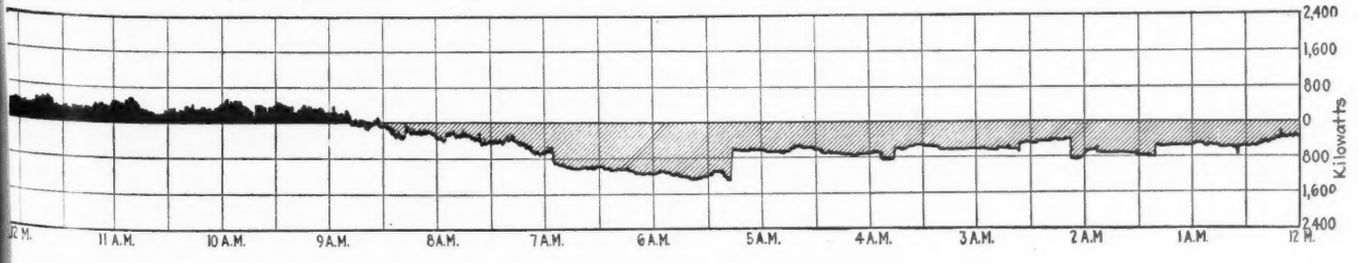
At woodworking plants and lumber mills there are large quantities of wood refuse. It generally costs more to ship this than can be obtained from its sale, so the refuse is allowed to accumulate.

A woodworking plant in New Hampshire uses the refuse in a steam electric plant, but there is more than enough of it to supply the plant's own power requirements. An arrangement was made with the Twin States Gas & Electric Company whereby the plant's power generating equipment is operated all night on the surplus wood and the output sold to the utility.

Thus the woodworking plant is saved the cost of disposing of the refuse while at the same time actually deriving a revenue from the power sold. In another case a saw mill generating power from wood refuse sells excess power amounting to 500,000 kw.-hr. per month. The plant is connected to the utility's system through a 3,200-kva. transformer, and, according to the agreement, the utility can, in case of an emergency, call for the entire 3,200 kva.

The sale of power from a Diesel engine plant to a utility cannot generally be accomplished at rates that will be profitable to both utility and private plant. This is because the increment kilowatt cost in a Diesel plant is generally equal to or greater than the increment cost of a kilowatt in a modern central station. There are, however, industrial Diesel plants that do sell power, but only because certain special conditions exist.

The Commerce Royalty & Mining Company, of Oklahoma, erected a 10,750-hp. Diesel engine power plant at Cardin, Okla., from which power is transmitted to 18 lead and zinc mines that this company operates. Connections



were made with the Northeast Oklahoma Railway and the city of Miami, both of which the Cardin plant supplies with electric energy.

Another example of an industrial Diesel plant selling power during its off-peak period is at the Sapphire Cotton Mill, Brevord, N. C. The power plant has two 200-hp. Diesel engines. During the week the mill operates 24 hr. a day and consumes about 1,250,000 kw.-hr. Over the week-end the Diesel plant frequently supplies power to the local utility.

A rather special case is to be found at the Fairbanks, Morse factory, where between 3,000 and 4,000 hp. of Diesel engine capacity is normally on the test floor. The generators driven by these engines are tied in with the local utility and their output is absorbed by the utility.

Power produced from process steam represents another condition that makes it possible for a private plant to generate power at cost low enough to permit sale to the utility. It has generally been recommended that the steam pressure of an industrial power plant designed to generate power from process steam should be selected, when possible, so that all of the power needed for manufacturing will be generated from factory steam requirements. But if it were possible to profitably dispose of excess power an entirely different situation would exist. Under such conditions it would probably pay to select for such a plant the highest practicable pressure, and so generate as much power as possible from the steam required by the factory. Only about 5,000 additional heat units is required to produce a kilowatt from process steam, representing a heat rate less than half that of the most efficient central station. The interest and depreciation on the power equipment are relatively low, because the major part of the boiler room investment is charged to the manufacturing process. Thus byproduct power may be produced very cheaply; in fact, such power costs less than the operating cost of central station power. Under these conditions it is possible for an industrial power plant to sell its excess power to a utility at a mutually profitable rate.

Although sale to the utility provides a profitable outlet for excess byproduct power, no industrial power plant has, so far as is known, taken full advantage of the possibilities in this direction. Nevertheless there are industrial plants that, either because the process steam requirements are large in comparison to power needs or because peak steam and power loads do not coincide, do dispose of excess power to the utility system.

Such a condition exists at the power plant serving the University of Michigan.[1] Byproduct power is generated from two back-pressure turbines of 1,250- and 600-kw. capacity. These units act as reducing valves for the steam, which is used almost entirely for heating purposes. The boiler pressure is 125 lb. and it is reduced in passing through the turbine to from 5 to 7 pounds.

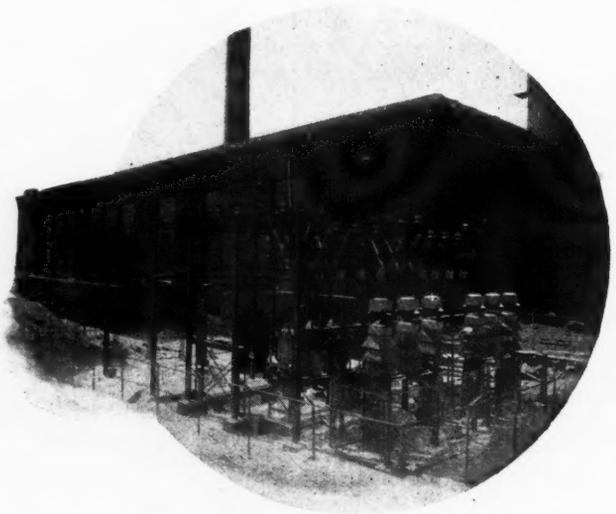


Fig. 7—Power house of University of Michigan at Ann Arbor

The fluctuating load of the various University buildings often makes it possible to generate more electric energy from the heating steam than can be used. An arrangement concluded in 1925 with the Detroit Edison Company made exchange of power possible and resulted in a considerable saving to the university. Under the terms of the agreement the Detroit Edison Company sells power to the university at 7 mills per kilowatt-hour delivered to the power plant and purchases surplus university power at 2 mills per kilowatt-hour. The table shows the amount of energy purchased each month during 1929. Between eight and nine million kilowatt-hours was generated by the university plant.

POWER, SOLD AND BOUGHT BY UNIVERSITY OF MICHIGAN

	Power Sold	Power Purchased	Steam Produced, Lb.
January	356,200	35,050	104,200,200
February	303,500	22,570	91,244,600
March	175,600	87,200	81,314,900
April	94,900	122,500	61,748,800
May	50,700	276,000	51,454,700
June	6,500	405,800	
July	Nil	696,500	150,000,000
August	Nil	644,000	
September	3,800	433,900	
October	75,400	148,000	60,797,800
November	188,700	75,200	82,618,830
December	267,600	84,900	114,419,800
Total for year	1,522,900	2,783,230	797,799,630

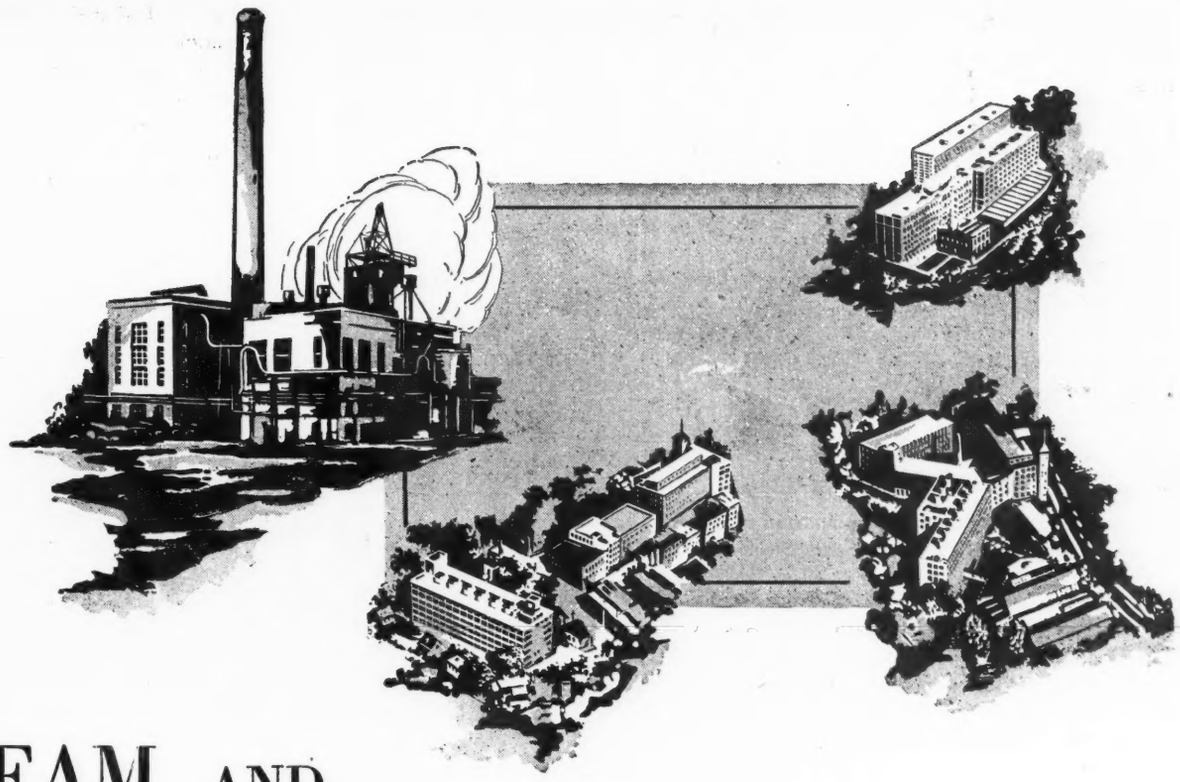
Heavy steam demands during cold weather by the various buildings on the campus make possible the generation of more energy than is necessary, and this is delivered to the utility's lines. During the summer months, with the heating load off, current is purchased from the utility, as it is more economical to do that than to generate.

The university plant thus floats on the power company's line. Both the incoming and outgoing energy is metered. The curve at the bottom of the two preceding pages show the hourly variation of sold and purchased power during a typical winter day.

A large textile and dye works in Massachusetts sold to the local utility 2,456,000 kw.-hr. during 1929. This industrial is served by three power plants, two hydro and one steam. The steam plant contains two bleeder turbines of 1,500- and 500-kw. capacity supplied with steam at 200-lb. pressure.

The contract with the utility carries a clause whereby it is required to purchase not less than 167,000 kw.-hr. a month, but not exceeding a maximum of 2,000 kw. This is classed as prime power. Any energy available in excess of this is sold through the local utility to the Pittsfield Electric Company at a rate of 5 mills per kilowatt-hour. There is also an exchange agreement with the utility whereby power may be purchased at times of heavy load or low-water conditions. During 1929 the amount of power purchased amounted to 1,678,000 kw.-hr. In the same year the steam plant generated 3,340,000 kw.-hr. and the hydro plants 3,150,000 and 1,404,000 kw.-hr. each. With the exception of Sunday, no restriction is placed upon the time of the day the utility can absorb power.

[1]Material obtained from Prof. J. E. Emswiler, engineering department, University of Michigan.



STEAM AND POWER FOR GROUPED INDUSTRIALS

An industrial central power house supplying power and steam to a group of diversified industries would be capable of developing these services at a very low cost. Examples of this situation are given by way of illustration

AN IMPORTANT FACTOR in the power field is the industrial central plant owned by a group of factories to which it supplies electrical energy, process steam and other power services. This situation possesses most interesting possibilities, and some claim that it portends an entirely new alignment of industry. Those who have studied the problem from all sides predict that while at present one industrial central plant is confined to supplying power to factories manufacturing similar products, the ultimate goal is the grouping about such power plants of a number of factories making different products. Through this arrangement the combined power and process steam needs of the several mills would tend to balance. That this would result in astonishingly low power costs is undisputable.

This idea of supplying power and steam from an industrial central plant is by no means a new one, but, as with high-pressure steam, was practiced, abandoned, and then taken up again.

Before Edison made electrical energy available to all, a general practice among realty men was to build a large loft or factory building, each floor being leased to a small manufacturer. Power was generated in the basement or adjoining shed, and delivered to each of the small manufacturers by belt or rope drive. This power was sold only on a yearly or monthly basis, and to measure the maximum demand, tests were run occasionally with shaft dynamometers.

With an increase in the capacity of factories new locations were sought and individual power plants installed, first with belt drive and later with electric drive. These power plants were, in present-day terms, small, and were equipped with 100-lb. tubular boilers and corliss engines, and, in New England, where water sites were available, with small waterwheels. So long as labor was procurable at $2 a day and coal at $2 a ton these plants were considered satisfactory, for competitors had the same type of equipment and comparable power costs.

The basic factors that led to the group power plant are not the same in all cases. In the majority of instances the plan was a result of the business expansion during and following the war. In the textile industries, for example, increased demand for cloth and sheeting

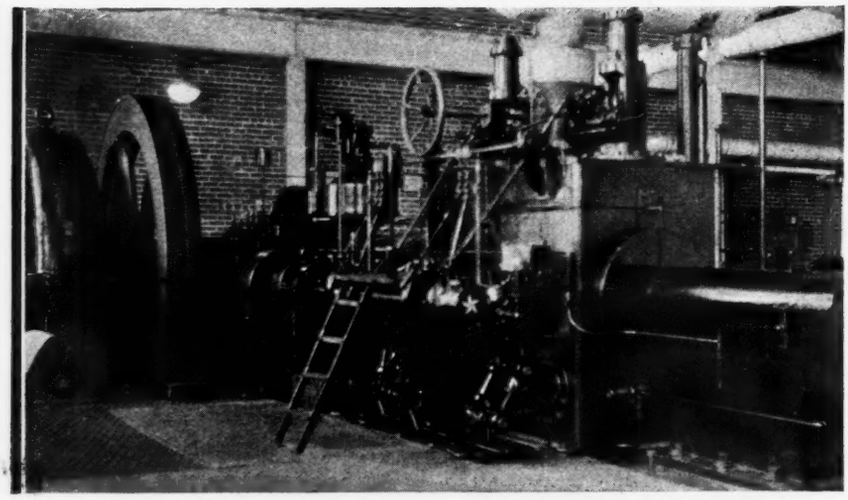


Fig. 1—This 600-kw. drop-piston valve engine in the power house of the Crystal Tissue Company is the largest engine of its type

encouraged the organization of new textile mills and the location of the factories in communities where power could be purchased cheaply; or if this was not possible advantage was taken of the advancements made in engineering to construct modern power plants.

The older mills, with their inefficient power plants, found themselves in a most unfavorable position. Many of these mills were too small to justify a modern power house of a size to give efficient results. The solution was found in a co-operative movement whereby an efficient power plant was built to supply two or more mills. Sometimes only the boiler house was built, to supply steam to the existing engines, to be followed at a favorable time by the installation of a central turbine and the abandonment of the small individual engines.

An example of this type of development is that of the United Elastic Corporation. Four small companies making elastic products in the town of Easthampton have combined as the United Elastic Corporation. Previous to the change, which is now being put into effect, each of these plants had its own boiler house. Three of the plants purchased power from the local utility, and the fourth relied upon belted engine drive. In addition, one of the plants purchasing power had installed a small waterwheel generator unit to operate in parallel with the outside power source.

A study of local conditions indicated attractive economies by abandoning the boiler plants in three of the properties and installing new boilers in the fourth property, where the engines were installed and the boilers of which were old and in need of replacement. The ten return-tubular boilers of various sizes in the four plants were replaced by two vertical, curved-tube type water-tube boilers, with multi-retort underfeed stokers. The new boilers were built for a pressure such that power generation as a byproduct of process steam requirements can be followed in the future when the present engines have served their usefulness. The two new boilers will have ample capacity to serve the full requirements of the four properties. Provision for spare boiler capacity is made by holding four of the old boilers in one of the other plants.

The new boiler plant distributes steam through overhead and underground welded steam lines to the various properties. The returns from all the properties are brought back to the central plant in lines paralleling the steam mains.

The project already shows evidence of considerable saving. This results, primarily, from better combustion, decreased cost of coal due to possibilities for using nut and slack instead of run-of-mine, from decreased labor costs in unloading and handling coal, and from the considerably reduced operating personnel. It is a good illustration of what can be done to reduce steam generation costs in similar situations.

At times product distribution problems in a particular industry may be such that a group power plant becomes economical. The tobacco industry is one where the time interval between manufacture and consumption must be short, if quality is to be maintained. With but a single factory and with no reserve stock a tobacco manufacturer would speedily lose his market, if the factory burned.

This has prompted cigarette makers to place factories in several towns. The Reynolds Tobacco Company originated in Winston-Salem, N. C., and for various reasons has adhered to the idea of centering its manufacturing in that city. To prevent total interruption in production the factories are placed in five groups, and at some distance apart. For some years each group had its boiler and generating units. Gradually these were interconnected to give a better heat balance, and, finally, a group power house was erected to serve all the buildings with power and process steam. This plant is equipped with high-pressure boilers and steam turbines. The capacity is such that modern highly efficient equipment could be installed, and a low steam consumption chargeable to power generation could be obtained.

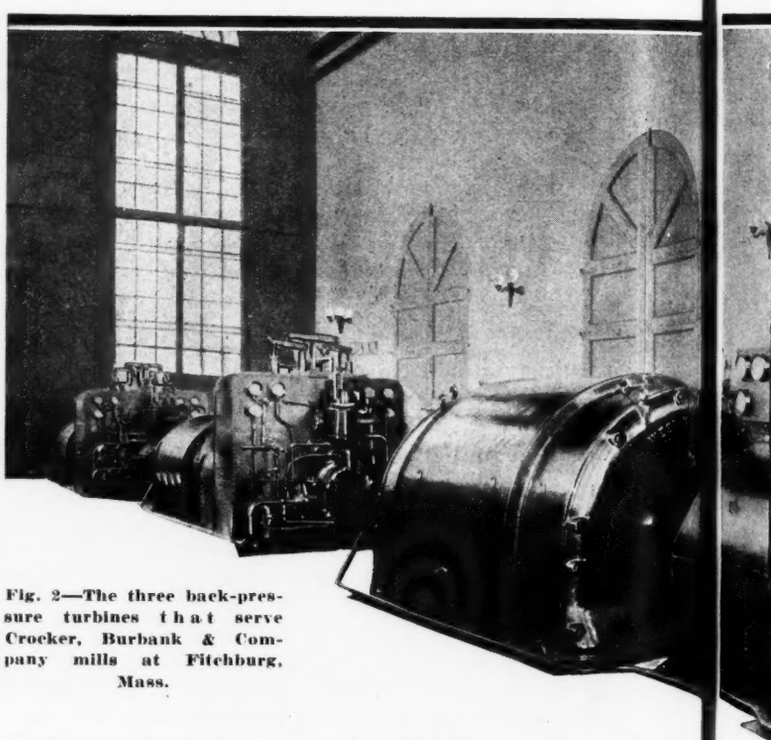


Fig. 2—The three back-pressure turbines that serve Crocker, Burbank & Company mills at Fitchburg, Mass.

On the other hand, in the same state are two mills owned by a textile company which are located about a mile apart. One used much more steam than is de-

livered by back-pressure turbines supplying the electric power. The other needs little steam but purchases a large amount of power. Installing an additional turbine and boiler would make it possible for the first mill to carry the electrical load of both mills and supply exhaust steam up to its process demands. Here is an instance where managements are not seizing upon an obvious opportunity to reduce their total power and process steam costs.

Still another industrial power set-up is that employed by the Illinois Steel Company and associated companies. At the South Chicago works of the Illinois Steel Company blast furnace gas is used in 3,750-kw. tandem, double-acting gas engines. This plant is interconnected with the blast furnace gas engine plant of the United States Steel Co., at Gary, Ind., and to the waste-heat steam plant of the Buffington, Ind., mill of the Universal Portland Cement Company. Power flows to and from the three plants as the mill loads and power plant output make necessary.

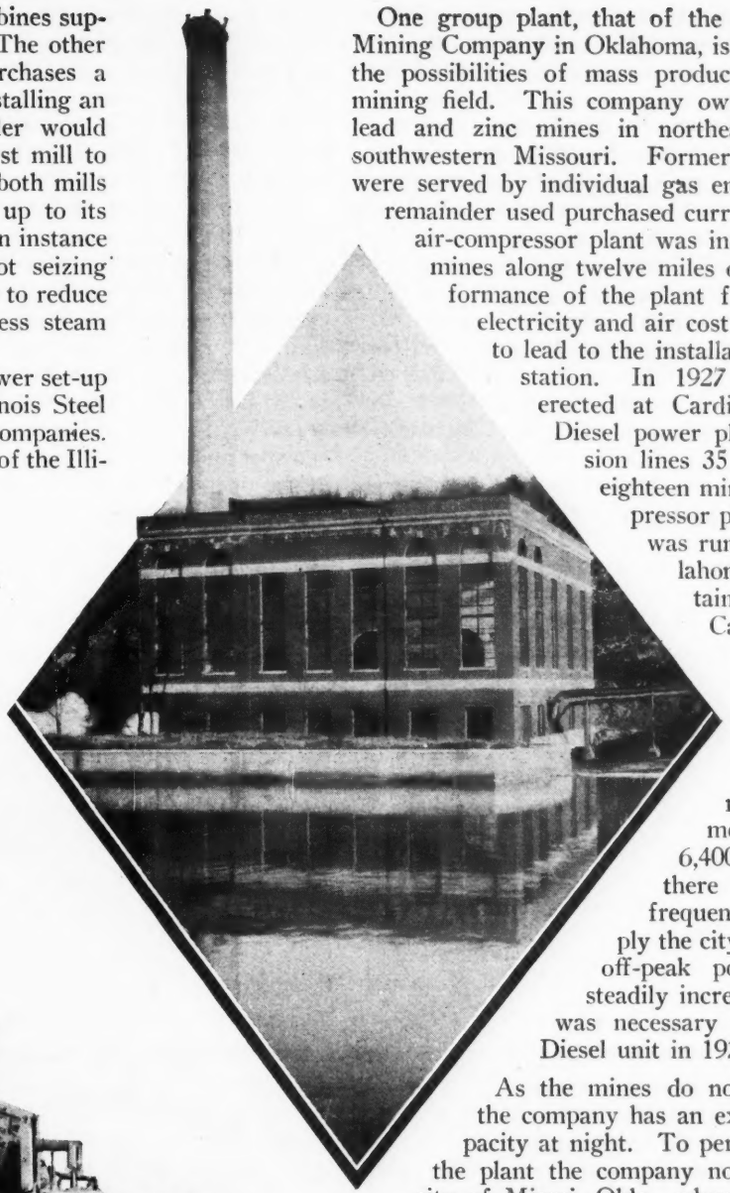
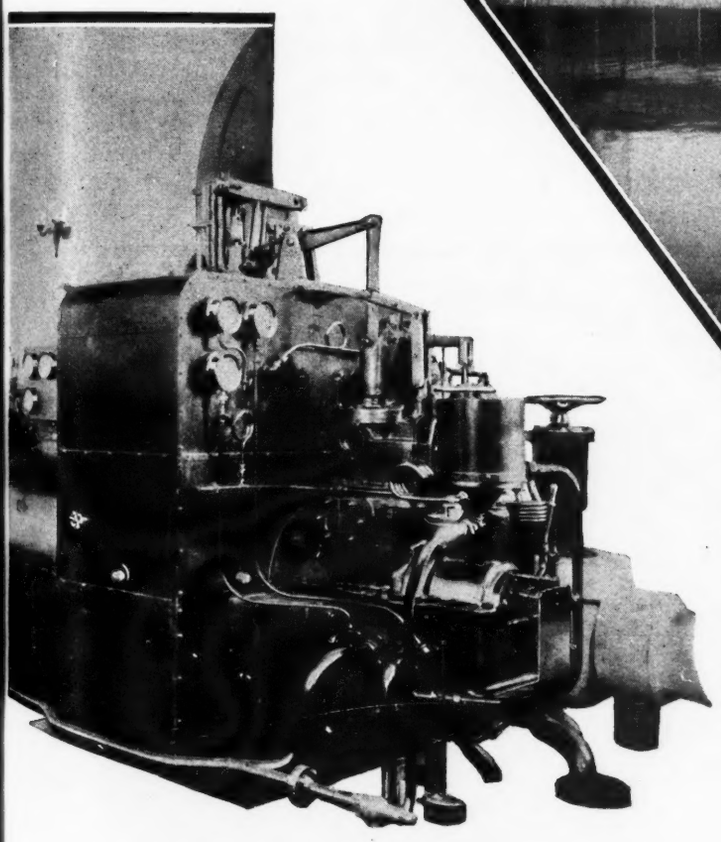


Fig. 3—This power house serves three mills of Crocker, Burbank & Company



One group plant, that of the Commerce Royalty & Mining Company in Oklahoma, is interesting as showing the possibilities of mass production of power in the mining field. This company owns a great number of lead and zinc mines in northeastern Oklahoma and southwestern Missouri. Formerly, part of the mines were served by individual gas engine plants, while the remainder used purchased current. In 1925 a central air-compressor plant was installed to supply air to mines along twelve miles of pipe line. The performance of the plant from the standpoint of electricity and air cost was so satisfactory as to lead to the installation of a group power station. In 1927 the mining company erected at Cardin, Okla., a 6,750-hp. Diesel power plant and ran transmission lines 35 miles in length to the eighteen mines and to the air compressor plant. In addition a line was run to the Northeast Oklahoma Railway, which obtains its energy from the Cardin power house.

When the plant was started in 1927 the connected motor load was 4,400 hp. exclusive of the railroad load. In ten months the load grew to 6,400 hp., and in addition there was added a 500-kw. frequency changer set to supply the city of Miami, Okla., with off-peak power. The load has steadily increased since then, and it was necessary to install a 4,000-hp. Diesel unit in 1929.

As the mines do not operate continuously the company has an excess of generating capacity at night. To permit a better loading of the plant the company now sells current to the city of Miami, Okla., whose municipal light plant is too small to meet the evening peak load. The arrangement avoids the necessity of a new unit in the municipal light plant and permits the mining company to derive some additional profit from its own plant. While the rate at which the energy is sold is unknown, obviously the city could afford to pay a price for the peak consumption equal to the cost of fuel plus the overhead charges of an additional unit.

The load factor is not high, due to the low demand at night, but in spite of this obstacle the plant will pay for itself in six years, based on the savings over purchased power at 1.75 per kw.-hr. The output and size of the mining company's plant undoubtedly permits power to be delivered to the switchboard for less than 1c. per kilowatt-hour.

In the paper industry it had been a common practice to construct a factory to contain one or two paper machines and the necessary auxiliaries, with a power house of the needed capacity. With an increase in paper sales, the mill often proceeded to erect another factory, with its complement of machinery, including a power house. The situation may reach the point where there are two or three power houses and paper mills in adjacent property owned by one firm. The power plants

are usually old, with low-pressure boilers and inefficient engines. A decided reduction in power costs has been obtained in many instances through a central power house.

The Crystal Tissue Company, Middleton, Ohio, may be cited as an example of how the group program reduced power and steam costs. The power department of the Crystal Tissue Company until recently furnished power and steam for manufacturing tissue paper, first in one mill that consisted of two, then three, paper machines, to which ultimately was added in another mill, which had at first one, then two, and finally, three machines. The old mill was driven by one corliss and two slide-valve engines by rope drives. The slide-valve engines were non-condensing and furnished steam for drying paper, while the corliss exhausted to a barometric condenser.

When the second mill was started another engine was installed for it near the paper machine. With the next machine came another engine, followed by another paper machine. Until this time the management had concentrated on paper making, and thought of the power department only as something necessary to keep the machines running. As the coal bill was getting to be a sizeable item, the management decided to electrify both mills. A 500-kw. geared turbine-generator was bought for each mill; a generator was belted to one engine in each mill, and the corliss was equipped with a uniflow cylinder for pulling the load not yet electrified. Each generator was connected to a certain part of the load, and if that generator went down the load went with it. The engines furnished steam for drying paper, while the turbines exhausted to surface condensers. Live steam was used if the engine did not furnish enough. If they furnished too much it went to the atmosphere.

As service and cost were still not what they should be, it was decided to move the turbine from the old to the new mill, purchase a new engine-driven generator, and run the three generators in parallel, supplying both mills from the bus. The engine would then furnish steam for both mills, the amount being regulated by the electrical load carried. The uniflow was to pull the belted load till it could be motorized.

That is the status of the plant today. Approximately 50,000 lb. of steam per hour is evaporated, 17,000 lb. going through the new engine to process, drying paper, and heating water for the beaters; 18,000 lb. goes to the two turbines; 5,000 lb. to the uniflow; 5,000 lb. to boiler feed and vacuum pumps; and 5,000 lb. to the steam hose, ash blowers and siphons. Of the 52,000 lb. of water fed to the boilers, 30,000 lb. is returned as condensate

During the year that the power was concentrated in one spot and the heaters were installed $10,000 was saved in the operation of the power department over the previous year. Part of this was due to coal, packing, oil, etc., saved; part to lower maintenance; and part to eliminating half of the operators, although the ones remaining were given a 15 per cent increase in pay. It is hard to estimate the savings made by the decrease in frequency and length of power interruptions, increased output, and quality of paper due to more uniform drying steam pressure, water pressure, and to many other intangible things that are the results of good operation, but they are considerable.

Another group power plant is that of Crocker, Burbank & Company at Fitchburg, Mass. This corporation runs nine mills in Fitchburg, of which three now take all their power and steam from a new central power house. Formerly they were served by hand-fired boiler and reciprocating engines, while power for the other mills was purchased from the local utility. To carry out the modernization movement the old power houses were

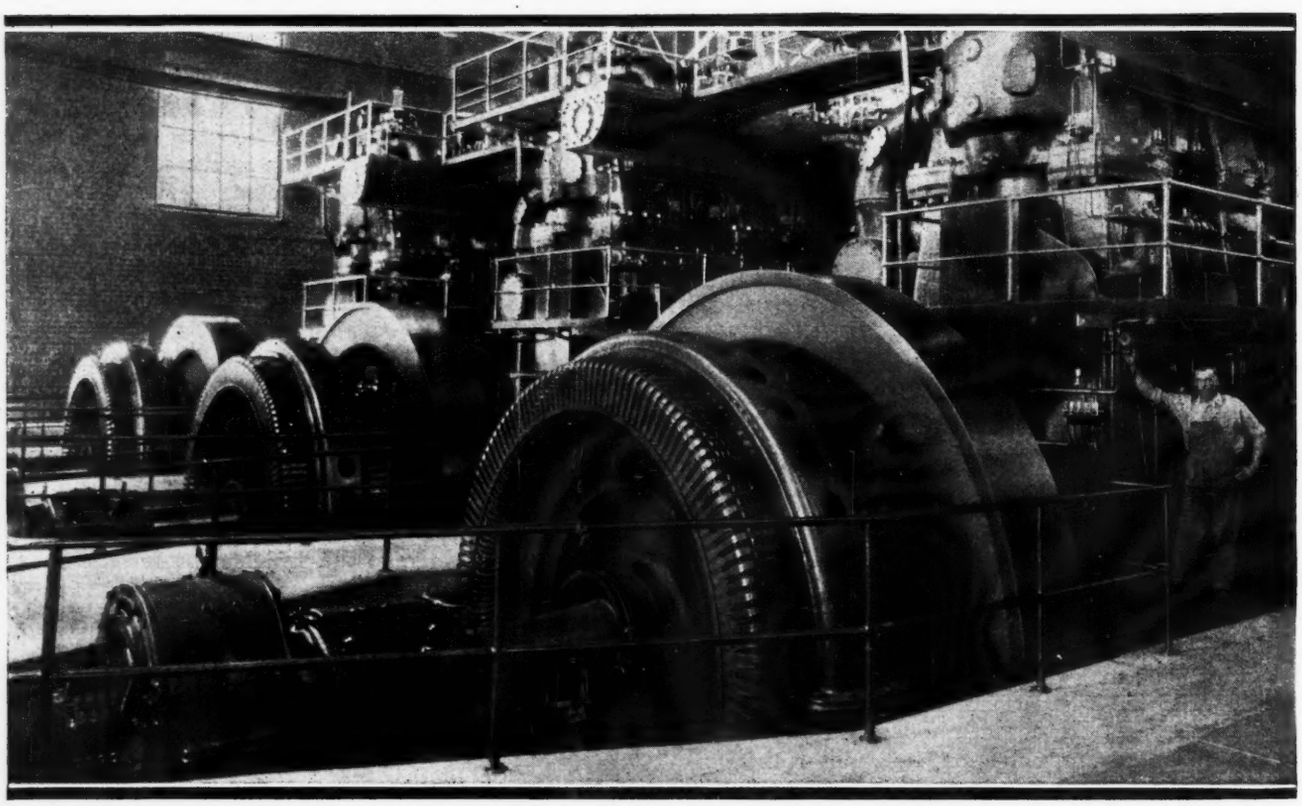
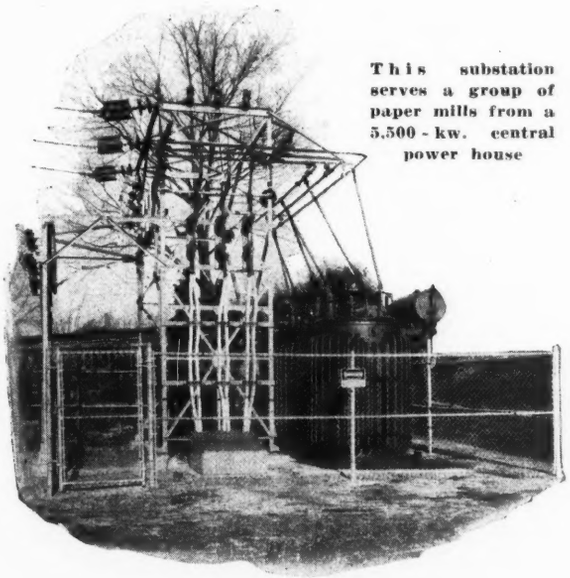


Fig. 4—This 10,750-hp. Diesel plant of the Commerce Royalty & Mining Company supplies power to the group of mines shown on page 831

dismantled and three turbines of 5,500-kw. capacity installed. The boilers were built for 400-lb. pressure. The balancing of the process steam and power demands is carried out to the highest degree. The turbines are loaded to the point where the 35-lb. exhaust steam meets the process needs. Power to paper machines only is transmitted over a private line. All additional byproduct power is delivered to the utility lines at the station, the total being less than that withdrawn for power and light at the mills. This arrangement was made possible only through the broadminded thinking of the New England Power Company.

Such a separation of manufactures into several groups, all served by a common power plant is practiced by the Smith Paper Company, which operates five mills near Lee, Mass. Originally all of the mills obtained power from the Housatonic River, but increase in paper making forced the management to purchase part of the power needed. Due to lack of synchronism in the operation of the mills a considerable amount of water was wasted when a plant was shut down.

Consequently, in 1923 two of the water power developments were combined to give a single head, and modern equipment was installed. Connection was made to the Pittsfield electric transmission line so that part of the water power could be delivered to the other mills, along with energy supplied by the transmission company. This situation is one where the industrial group power house idea is carried, but in conjunction with purchased power.



This substation serves a group of paper mills from a 5,500-kw. central power house

The Paul A. Sorg Paper Company,[1] along with its affiliated companies, the W. B. Oglesby Paper Company and the Frank Smith Paper Company, recently completed a steam and electric power plant of capacity sufficient to serve all three concerns, thus centralizing the power facilities serving these plants.

For several years previous to the inception of the new plant the demand for steam and power grew steadily greater and greater, until only temporary expedients could satisfy the immediate requirements. The condition resulted in the use of miscellaneous engine and motor drive, the purchase of some power, and the operation of two boiler plants at maximum rated capacity. Reserve equipment no longer existed, as all equipment was needed for regular operation. The new plant contains two 6,000-sq.ft. bent-tube boilers capable of delivering 72,000 lb. per hour of steam at 400 lb. pressure and 200 deg. superheat, but designed for a normal delivery of between 40,000 and 60,000 lb. of steam per hour. Coal is pulverized in unit ball mills and fired through turbulent-type burners. Preheated air is secured from a tubular preheater, and is used both in the pulverizer as primary air and in the burner as secondary air. The furnace chamber is lined on two sides with refractory covered water walls. Economizers are provided in addition to the air pre-

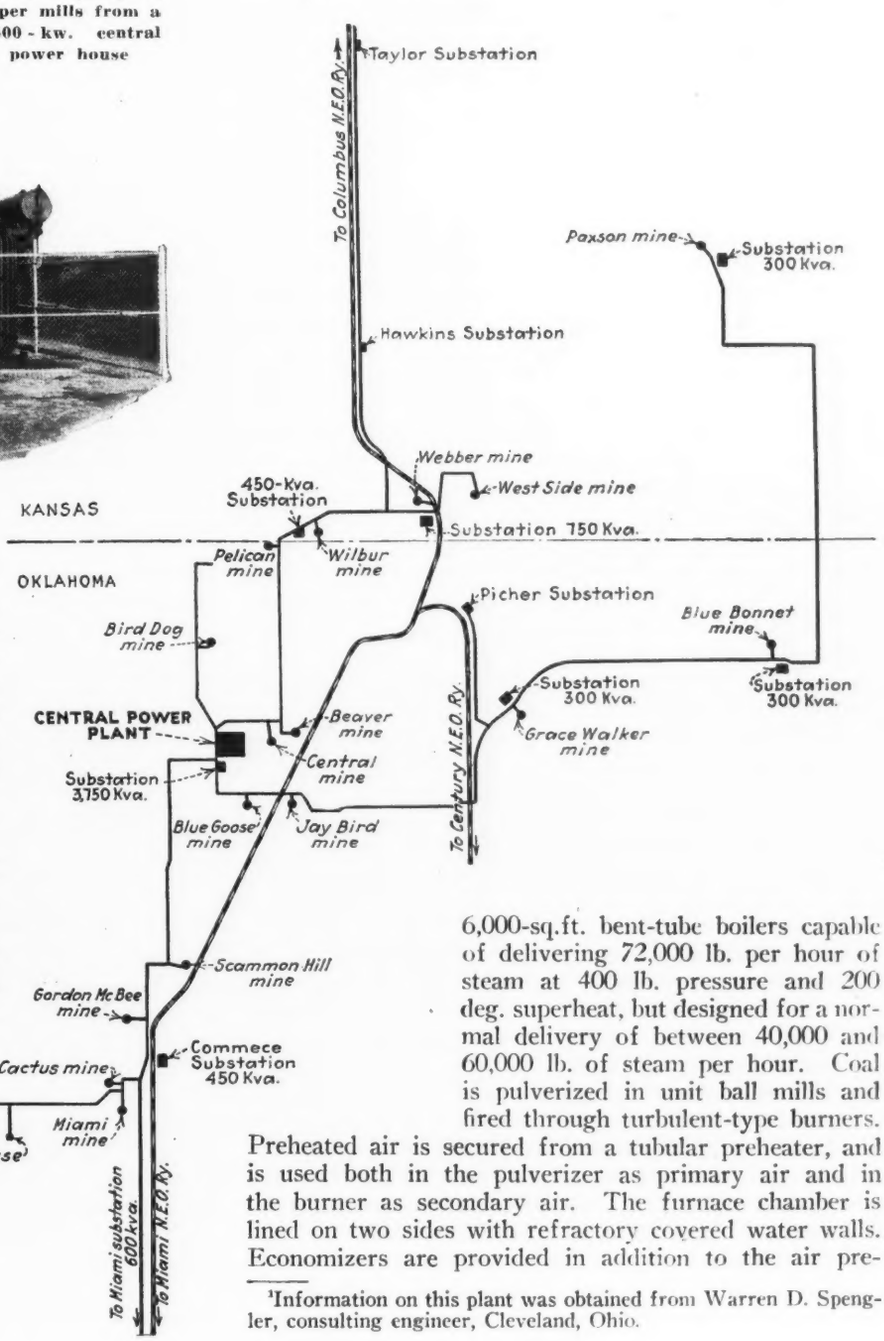


Fig. 5—This group of mines owned by the Commerce Royalty & Mining Company, the N.E.O. Railways and the City of Miami all receive power from a central power house

[1]Information on this plant was obtained from Warren D. Spengler, consulting engineer, Cleveland, Ohio.

heaters. In the turbine room are two 5,000-kw. units arranged to allow steam extraction at 50-lb. and 20-lb. pressure, and condensing at a 28-in. vacuum. The 20-lb. extraction is fully automatic, but the 50-lb. extraction is controlled through a reducing valve.

The steam for process purposes, when extracted, has more superheat than necessary, the amount depending on total steam taken by the turbine. Automatic desuperheaters are provided to control the steam condition so that it will be in a dry, saturated state when used in the mills. Both surface- and spray-type desuperheaters are employed, the type being dictated by the relative temperature desired and the source of water for desuperheating.

Energy is generated at 6,600 volts. The bus and the 6,600-volt switches are in separate switch and bus rooms. All power is transmitted to the mills through armored cable laid in the ground to mill transformer banks, where it is stepped down to 440 volts.

Indicating, recording, and integrating instruments permit the chief engineer to follow and analyze operation of the plant with a view to attaining the lowest operating cost, anticipating trouble and correcting for it.

As a reserve supply for station power, a small automatic hydro-electric station was built, taking water from a canal that was formerly allotted to three waterwheels that drove mill shafting.

Since the power plant went into operation normal production of the mills has increased over 50 per cent, necessitating a corresponding increase in demand for steam and power, which the new power plant has readily met. In the chief engineer's report to the company's management, the cost of power for 1929 is indicated at 8½ mills per kilowatt-hour. The cost of steam generated at 400 lb. is given at 28c. per thousand, the cost of 60-lb. steam at 21c. per thousand, and the cost of 20-lb. steam at 16.8c. per thousand pounds. These costs include charges for coal, oil, labor, maintenance, taxes, insurance, depreciation and interest. The curves of Fig. 6 indicate the hourly watt-meter readings of power supplied to each of the three plants, and the total load carried by the turbine for a typical day. It should be noted that the variation in the demand for power by each of the mills combines to give a somewhat steadier load on the centralized plant.

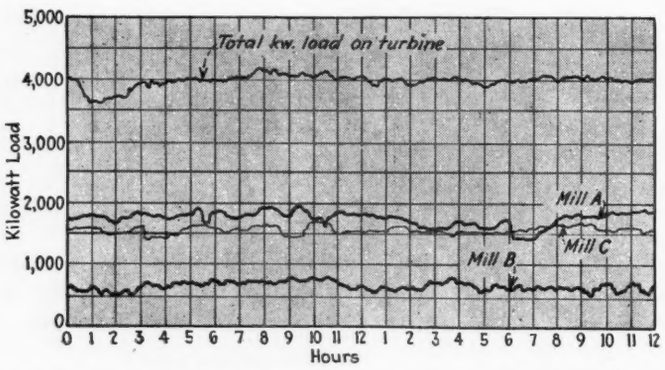


Fig. 6—Combined load curves of the Paul A. Sorg Paper Company

Grosvenor-Dale Company, manufacturers of cotton cloth and sheeting, effected a yearly reduction in power costs amounting to about $32,000 by centralizing and redesigning its power and steam facilities. The two mills of the company are 1½ miles apart, on the Quenibaug River, Conn. Each mill originally had its own boilers and engines. Mill No. 1 had one 1,000-hp. cross-compound engine, and Mill No. 2 had four compound engines totaling 3,900 hp. All were belt connected to line shafts. These engines were supplemented by three hydro plants.

Consolidation of power facilities resulted in the shutting down of the old engines in both mills, the electrification of mill drives, and the installation in Mill No. 2 of a 2,200-kw. turbine followed by a second bleeder unit of 6,000-kw. capacity.

In the oil fields the group power plant has not made the headway one might look for. The Magnolia Oil Company several years ago installed a Diesel plant at Loveland, Texas, to supply electricity to the Magnolia wells in that field. This plant was later sold to the Texas Power & Light Company, which now sells energy to the Magnolia Company at a price equal to the latter company's cost at the Loveland plant. As oil field pumping is a uniform load, there seems to be an opportunity for an oil company to use motor-driven pumps and a central power house in fields where it has many wells of proved production.

As the efficiency of a power plant can be made to increase with an increase in capacity, it follows that the group plant offers distinct advantages. Higher pressure can be used without excessive boiler installation costs and a more efficient turbine can be obtained in the larger capacities.

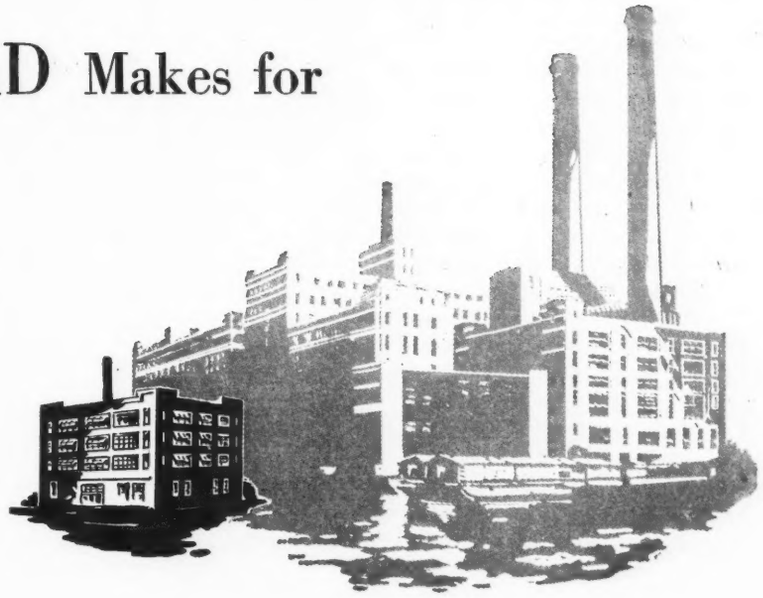
The investment cost will be much less per unit of capacity, which means a lower capital charge. As it is not unusual to find the unit capital charges greater than the total operating charges, a reduction of one-third in the capital investment will bring about a net saving of over one-sixth in the total power costs. Then too, the installed capacity can be less than the sum of the capacities if new individual power houses were to be built.

Another, and frequently the largest, saving is that in labor charges. No more men are needed to operate a 2,000-kw. plant than a 300-kw. individual plant. Consequently, the reduction in labor is more or less in relation to the number of power houses discontinued.

While the industrial central power plant has so far been confined to situations where one corporation runs several factories producing similar goods, this is not the field where that type of plant offers the greatest efficiency.

If managements are sufficiently far-sighted to appreciate the advantage of co-operative power, the future development will be among factories making a diversity of products. If, alongside a factory using much process steam and little power, there were placed a second mill needing much power and little process steam, a heat balance could be obtained that would reduce power and steam costs to a minimum. It must be conceded that it is not always possible to obtain a sufficient co-operative spirit among managements to make such a plan workable. But the idea offers sufficient monetary profit to induce the necessary mutual confidence among factory owners. The power plant may be owned collectively or a separate corporation may be formed to operate the plant, the stock to be owned by the several factories. A third plan, of better management structure, is for an entirely separate corporation, a public utility for example, to construct a power plant in the center of a factory development and sell both power and process steam.

WHEN GROWING LOAD Makes for GENERATION



Many small manufacturing establishments purchase power. As the load grows, particularly where process steam is required, local generation may appear more attractive. Often the best solution of the power problem in such cases is a combination of purchased and locally generated power

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AN EARLIER article in this number (page 816) discussed the problem of growing load in connection with industrials already generating power. The present article again considers the growing load, but this time as applied to the small factory which has been purchasing all of its power. In both cases a combination of purchased and locally generated power is sometimes the most economic method of supplying the increased load.

Growth of manufacturing plants brings new problems. In particular, the power problem changes as the load increases. Under certain conditions, the small manufacturing plant, buying power and producing heating steam in low-pressure boilers, begins to see its power problems in a new light when growing production builds the power bill to sizeable proportions.

A point may be reached in this development where the industrial plant feels, rightly or wrongly, that locally made power might be cheaper. This leads to a survey of the whole power situation—often with the co-operation of the utility. If the final result of this study demonstrates to the industrial's satisfaction that local generation would be cheaper than purchase of all requirements, the utility is faced with the loss of a substanial and increasingly attractive block of its load.

Assuming that local generation is actually cheaper in a given case, or at least that the industrial is so convinced, a third possibility is often overlooked, to the detriment of both parties. It frequently happens that the economic solution of this problem is neither local generation nor purchase to the exclusion of the other. A combination of purchased and locally generated power may give a lower cost than either alone and thus save for the utility a large portion of the load that would otherwise be lost entirely.

The purpose of the present article is to discuss briefly some of the factors that enter into this problem, which is of practical interest to utility and industrial alike.

It has repeatedly, and correctly, been stated that each plant is a law unto itself and that no general statement can be made as to the superiority of purchased power over that locally generated; or vice versa. Too many factors are present for a general answer.

There are, however, some generalizations that may be made regarding certain factors. Take, for example, the factor of size—referring to the size of a manufacturing plant. Increased size means increased load. This, in turn, lowers the unit cost of locally generated power. It is a truism that the cost per unit of capacity of boilers, turbines, generators, and other power equipment decreases as size increases, and that this decrease in unit investment cost is accompanied by a decreased fuel consumption per 1,000 lb. of steam or per kilowatt-hour.

Moreover, this fall of unit investment cost and fuel consumption is accompanied by a substantial reduction in labor and supervision charges per unit of output. It is obvious that the operating personnel and cost of executive supervision for a 1,000-kw. plant may be practically the same as that required for a 2,000-kw. plant. With the same load factor, then, *unit* labor and supervision costs for the 1,000-kw. plant may be nearly double those for the 2,000-kw. plant. The rate of change of these elements with load is far more marked within the range of usual industrial loads than is the case with central stations in the range from, say, 50,000 to 500,000 kw.

So far the size factor works entirely in one direction—in favor of locally made power as the load increases. Working in the opposite direction is the factor of price of purchased power. As the load increases, the cost of purchased power generally goes down. If it went down fast enough it would, of course, throw the balance more and more in favor of purchased power as plant size increased. In most actual cases, however, the cost of locally generated power falls more rapidly than the cost

of purchased power as the plant and the load grow larger. This is certainly true in practically all cases for very small manufacturing plants. Thus, if one starts with a very small manufacturing plant purchasing all power, because it is cheaper to do so, increased size makes locally generated power more attractive. This trend may or may not continue to the point where local generation is actually cheaper.

Let us consider, then, what may happen with the natural growth of an industrial plant originally purchasing all its power and generating steam for heating and process in low-pressure boilers. As the plant grows the power bill grows with it until eventually the owners turn their attention to the possibility of generating power. The resulting investigation may reveal the fact that a substantial portion of the load can be generated at rather low cost as a byproduct of process steam, while additional load generated from steam exhausted to condenser or atmosphere will cost considerably more than purchased power. It may happen that the saving on byproduct power will more than offset the higher unit cost of the portion that must be generated by condensing equipment or by prime movers exhausting to atmosphere.

AN ECONOMICAL solution in many such cases is a combination of locally generated and purchased power. The plant under this plan generates all or a great part of the power that can be obtained as a byproduct from process steam, and buys its remaining requirements from the utility at a fair rate which takes account of the rather poor load factor often associated with this excess load.

In short, in the case under discussion, the three primary operating possibilities may be arranged as follows, in order of their economic desirability from the standpoint of the manufacturing plant: First, generate all or part of the available byproduct power from process steam and purchase the remainder. Second, generate all power locally. Third, purchase all power.

Failure by either the utility or the industrial to recognize the true situation will result in loss to both parties. If the possibilities of co-operation are overlooked, or simply disregarded, the industrial will naturally change over to complete local generation as the next best solution, while the utility will miss an opportunity to supply part of the load with mutual profit.

Many far-sighted utilities now appreciate the existence of this situation and encourage *suitably situated* industrial customers to purchase part of their power rather than generate all locally, which would be the second best procedure in such cases. This situation promises to become increasingly common as industrial power decisions are based more and more on economic analyses. It is obviously proper in such cases for the utility to charge a higher rate for energy because of the smaller amount used and to take care of lower load factor through equitable demand charges.

Recent high-pressure advances have introduced a new factor into this situation. As has been pointed out repeatedly, the amount of byproduct power that may be extracted from process steam increases as the boiler pressure is raised. This increase is particularly noticeable where the process pressures are well above atmospheric. Thus a private plant which until recently could not possibly generate all of its power as a byproduct may now be able to do so by going to 400-500, lb. or even higher pressures.

There are, however, certain objections to high pressures. Their use naturally introduces some complication into the operation of the plant and increases the investment. In addition, with a high percentage of make-up, feed-water problems may present many difficulties in spite of recent progress in this field.

It is true that the feed-water problem can be completely solved by the installation of evaporators as "reducing valves" to produce process vapor from the main steam supply to the turbine. These evaporators may be installed either before or after the turbine. In either case, however, the industrial must be prepared to make a substantial investment in evaporative equipment. To keep this first cost within reason a considerable temperature drop through the evaporator must be provided for. This, in turn, requires a further increase in boiler pressure to produce the load from the given flow of process steam.

It is therefore apparent that the supply of additional power by higher boiler pressure, while entirely feasible from the operating standpoint, cannot be accomplished without additional expense.

Similarly, condensing operation for part of the load involves certain complications. Frequently, circulating water is not available. The generating cost of power produced in small condensing units far exceeds that of the central station.

THE Diesel engine is a factor of growing importance in situations such as this. Within the limits of the process load no prime mover can compete on a heat-consumption basis with the back-pressure engine or turbine. But the moment the byproduct power capacity is exceeded the net heat consumption per kilowatt-hour jumps from 5,000 B.t.u., say, to perhaps 20,000 for a small condensing unit, and as high as 40,000 for non-condensing operation. These assumptions are based on normal steam pressures.

Here the Diesel engine steps in with a net heat rate of about 12,000 B.t.u. per kilowatt-hour. After allowing for the higher heat cost of Diesel fuel, the oil engine may prove to be an economical addition to a byproduct power plant.

It is seen, then, that the central station, to secure this excess industrial load, must compete not with the total power cost of the industrial, but with the cost of that portion which would otherwise be generated in a somewhat more expensive manner. Often this competition can be met at a rate which will assure a profit to the utility, making due allowances for the nature of the load.

Another factor to be considered, in comparing the purchase of additional power demand with its local generation, is the financial situation. The utility can frequently obtain funds for plant construction at a lower rate than can the industrial. This situation affects the comparison even where surplus funds are already available. On the other hand, it must be recognized that industrial installations are more easily financed today than some years ago.

CONTRACTUAL RELATIONS

OLD FUNDAMENTALS NEW APPLICATIONS

A new and difficult art is in the making. The drafting of contracts covering the various co-operative relationships is no simple task; yet there are certain economic fundamentals, here discussed, that must underlie all such agreements

THE various special co-operative arrangements between utilities and industrials require special contracts. To draw up such contracts might seem a simple matter, but that is not the case. In the first place, the relations involved are more complex than those found in simple purchase of power in the traditional manner.

Another factor is equally important. Many co-operative arrangements involve special investment by one or several parties. Where future developments might endanger this investment, a long-term contract is essential. It is evident that the drafting of a contract which will provide for the contingencies of the next five, ten, or fifteen years, insuring reasonable profit to both parties, and protecting the investment of both, is a most difficult matter.

Where no special investment is involved, short-term contracts give adequate protection. They can be far less elaborate than long-term contracts, since periodic revisions will take care of changing situations or correct any unfairness to either party that may result from too great simplification of the agreement.

Before any contract is made, it should be clear that the arrangement to be covered will be profitable to both parties. A contract cannot bring such a profit into existence unless it is inherent in the economic set-up. If party *A*, for example, is to buy energy at certain times from party *B*, it is fundamentally necessary that *B* be able to furnish this energy at a net cost less than it would cost *A* to generate the same energy or to obtain it elsewhere.

The size of this difference measures the attractiveness of the co-operative relation, and total price paid for service must necessarily fall somewhere between these two limits if both parties are to profit. Within this "profit band" determination of the exact price will be a matter of barter, often terminating in a fifty-fifty split of the saving.

In considering problems of this sort, one should study, first, the energy relations involved; second, their economic implications; and, finally, the legal arrangements necessary to take maximum advantage of the economic possibilities.

A study of the problem shows that certain general fundamentals may be laid down for this class of contracts. For example:

1. The importance of having a sound contract is proportional to the special investment tied up in such a way that its value would be destroyed if the arrangement were changed.

2. Where such investments are involved, the contract should not only take care of operating costs and yield a fair profit to both parties, but should also provide a surplus from which the investment can be written off during the life of the contract.

3. Some provision should be made to indemnify the maker of the investment if changed conditions, or default of the other party, render it useless before the investment is retired out of surplus.

4. Where the special investment is made by a utility for use in a co-operative arrangement with one or a small number of industrials, the business of the industrial or the group should be carefully examined by the utility, just as an investor would examine a business before buying stock in it. In this the utility should consider not merely integrity, financial standing, and technical skill of the organizations, but also diversity of product and future prospects in a competitive field.

5. All contracts, regardless of investment, should consider the *nature* of the loads as well as the *quantities* of steam and electricity involved.

6. Contracts should avoid setting up legal barriers to free flow of energy, where such flow might conserve fuel, management, labor, and investment. In short, make maximum economic use of the diversity factor.

7. As a matter of policy, it is well for the utility to use standard rate schedules for energy sold to an industrial, as far as they are applicable.

8. Take maximum advantage of possible pooling of

investment. (One large plant is generally cheaper and more efficient than two smaller plants for the same service. Site, building, siding, coal- and ash-handling equipment, and spare units need not be duplicated. Labor cost per unit of output is lower for the single large plant, as is the cost of supervision and design. Incidentally, a higher grade of talent for design and operation may be afforded.)

Item 7 points to the desirability of using standard rates for energy sold, as far as applicable. It is realized that such rates can be used only in part, and that special co-operative relationship may necessarily involve special arrangements.

Of the various relationships discussed in this number, one of the most interesting, from the contractual point of view, is that where a utility supplies both steam and power to one or more industrials. Many factors must be considered here.

Generation of byproduct power from steam sold will be an important consideration. If there is a large excess of such power available in amounts and at times fitting nicely into the demands of the utility system, and if the plant is suitably located in the system network, conditions are favorable for its installation.

The element of risk, which has already been discussed, must be given special thought here. If a single industrial is to be the sole customer, it must rank very high in business stability. A group of customers close together, with diversified products, reduces the risk. Risk is also reduced if the plant is on a river, and if provision is made in the design for addition of condensing low-pressure turbines should the industrial load fail at some later time. Distance of the utility plant from the industrials using its steam is a vital matter, as long-distance steam transmission is expensive.

Desirability of an arrangement having been decided, careful consideration must be given to the contract itself. In general, a contract based on a simple flat rate for steam and electricity will be defective in several respects. It will not properly guard the investment. It will not take care of varying costs of production as the ratio between steam demand and electric demand changes.

Combined cost of generating steam and electricity will be least when steam capacity is fully utilized and electric demand exactly equals the amount of byproduct power that may be generated from this steam. Some means should be devised in the contract to take account of relative variations in steam and electric demand. The problem is not simple. Where, however, several industrials are supplied with steam and electricity from a single special plant, it may be best to avoid this problem altogether by setting up sliding rates and demand charges for steam and electricity separately, after analyzing the probable steam and electric loads of the various industrials to make certain that the net result obtained will be within reason.

With a single consumer it is possible to go further. There it will generally be best to provide for the investment very definitely. Method and amount of payment should provide for at least all equipment that is held ready for exclusive use of the industrial. It should make special provision for any excess power demand that must be generated by condensing turbines or by power drawn from the general system.

Conversely, the industrial should get some kind of credit for excess power that the utility may generate as a byproduct from steam supplied to the industrial. But here further complications enter. It matters greatly whether this excess power comes on the system's peak or off-peak load, or whether it is distributed uniformly over 24 hours.

One simple and logical plan is for the utility to charge the industrial for high-pressure steam from which the low-pressure steam delivered to the industrial is produced. Byproduct electricity generated by this steam before it passes to the industrial carries no additional energy charge. It does carry a charge for special operating services. The remaining expense of producing this electricity may be taken care of by billing the industrial for fixed charges on equipment installed for its benefit.

Under such an arrangement it will be necessary to credit the industrial for any power from its generator that is delivered to the utility line. This credit may well take the form of a payment equivalent to coal saved the utility. If a certain excess is available to the utility at all times, then, of course, part of the fixed charges should be carried by the utility. On the other hand, the industrial should carry loss due to poor feed water caused by failure to return condensate equal to the process steam received. Again, if the industrial is permitted to draw power at times from the rest of the system, a special demand charge for this is properly made.

Regardless of legal and mechanical devices involved, net economic results of a sound contract for the sale of steam and power to a single industrial from a special utility plant should generally include the following:

1. Complete pooling of electrical loads, with consequent improvement in diversity factor and saving in fixed charges and operating cost.
2. Pooling of generating capacity in a single structure, with consequent reduced fixed charges per unit of output for boilers, turbine-generators, auxiliaries, spare units, building, land, coal and water facilities, etc.
3. Pooling of technical personnel, with consequent savings through better design and operation, and reduced personnel cost per unit of output.
4. Pooling of fuel purchasing, with consequent saving in price and handling cost.
5. A process steam supply exactly meeting the demand of the industrial plant.
6. Complete recovery, and use in the common electrical pool, of all byproduct power that can be produced from this process steam.

When the utility only buys power from the industrial it is forced to install transmission and transforming equipment that could serve equally well to deliver power at other times. Thus the complete use of equipment tends to favor power exchange rather than simple purchase by the utility in any case where the industrial could use some outside power. In short, complete pooling is possible without additional investment.

Here the problem of investment comes in. Regardless of actual ownership of facilities, fixed charges on them should ultimately be carried by the party that benefits. Where the industrial buys only, its payments must take care of the entire special investment. Conversely, if equipment is installed solely to deliver energy to the utility, the utility should pay fixed charges on this equipment. Where energy flows both ways through the same

equipment, fixed charges should be divided in some equitable fashion between the two.

Inter-connection of utility and industrial plants brings up some interesting problems, particularly where the industrial has dump power available at certain times. Such examples occur in the steel industry (because of waste heat) and among industrials with private hydro-electric plants.

Normally, the utility increases its generating capacity in blocks to take care of several years' growth. Just after installing a new plant the utility has a surplus of power which it would pay, if necessary, to sell at any price above bare operating cost. Conversely, the utility can often postpone investment in generating stations or equipment by purchasing excess power from industrials. It is not a simple matter to provide in a contract for such periodic variations, but the matter should be given consideration. Contracts for power exchange should provide also for possible future increases or decreases in fuel cost.

Where an industrial sells power to a utility the contract must take account of the demand and the amount of energy used. The industrial cannot agree to supply more than its available free capacity. On the other hand, it must try to find a market for all dump power generated from waste heat or hydro that would otherwise go to waste, and for as much as possible of its excess power-generating capacity. The first is worth selling at almost anything it will bring, the latter at a price that will leave a profit above operating charges only, including fuel required. In one case considered in this number the utility agreed to purchase not less than a certain number of kilowatt-hours per year, and not to exceed a given maximum demand. In another case, where a certain capacity was definitely allocated to the use of the utility, the utility agreed to pay a certain fixed yearly sum, regardless of the actual number of kilowatt-hours drawn from this source.

Where the utility sells both steam and power to the industrial, and also in the cases of power exchange and of power purchase by the utility, the ownership of transmission facilities is a problem to be considered. Whether they be owned independently by utilities or industrials, or jointly, fixed charges should be carried directly or indirectly by those who benefit.

More difficult problems of ownership arise where a special plant is built to serve a single industrial, or a group of industrials. The simplest arrangement is for the utility to build the plant and sell it outright to the industrial, the utility to supervise operation and charge the industrial for operating costs, plus a service fee. This arrangement is ideally simple and fully protects the utility against future changes in the business of the industrial.

Generally, however, the utility is in a better position than the industrial to make large investments. In that case the utility may build the plant and sell it to the industrial on the instalment plan, under an arrangement providing for utility operation.

Again, the plant may be owned and operated by the utility, but leased to the industrial. Here, to minimize the risk, rental should retire investment within a reasonable period. If the plant is to be owned jointly by utility and industrial, it may be best to organize a separate company, stock of which is jointly owned by the two.

In some cases the utility installs special equipment in the plant of the industrial. For example, a utility might install waste-heat boilers and turbines in a steel plant, paying for waste heat used and selling electricity at low rates to the industrial. Such an arrangement, of course, is justified only where the utility's outside market for surplus power gives it an advantage.

Ownership by the utility of equipment in the industrial plant involves some risk and leaves the way open for dispute. These matters must be carefully considered in preparing such contracts.

Where the industrial owns the plant and the utility operates it, the only advantage, aside from possible greater operating efficiency of the utility, is inter-connection with the rest of the system.

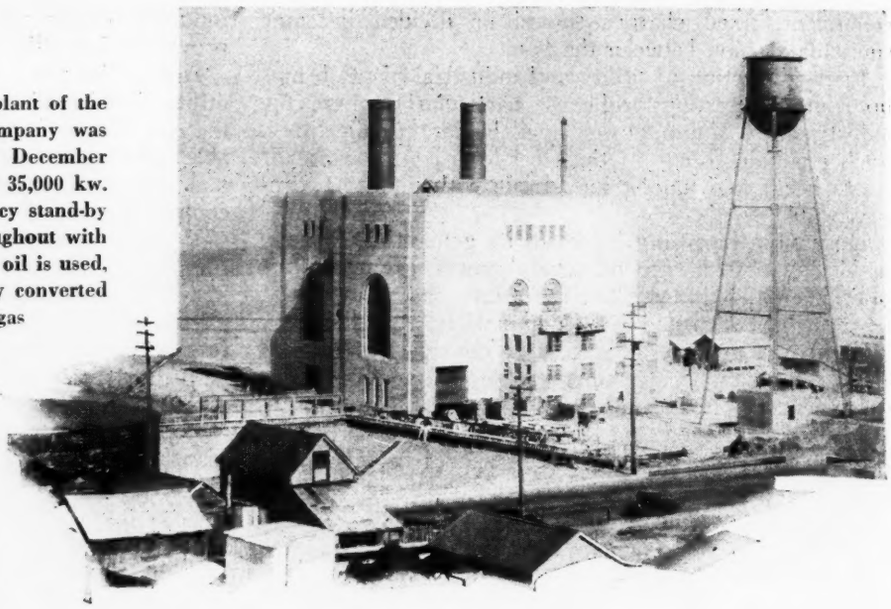
Where a plant to supply steam and power to several industrials is to be owned jointly by them, with or without the utility, embarrassing complications are generally best avoided by forming a special company whose stock is held by the interested parties. If, under this arrangement, the utility takes care of operation, it is naturally entitled to a special fee for such service.

The utility is frequently made a party to such group arrangements, because the group thereby gains an outlet for surplus byproduct power and a source of supply for excess power requirements.

In the foregoing paragraphs no attempt has been made to give a complete picture of the various contractual relationships, or even of all fundamental principles involved. Lack of space, as well as the present state of the art, makes this impossible. Enough have been given, however, to indicate some of the major problems to be considered, and general methods of attack.

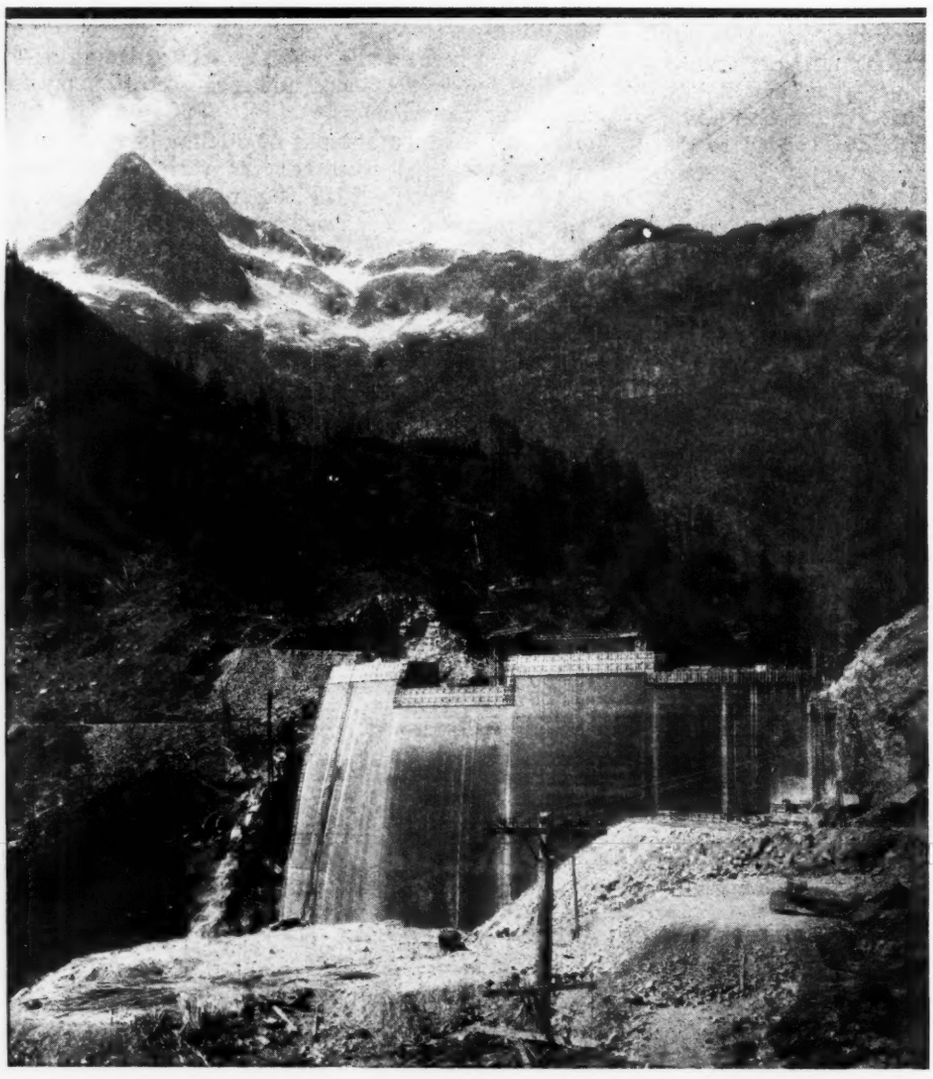
Future developments of these relationships, and contracts that define them, will be a highly specialized art, demanding the best engineering and legal talent.

In addition it will call for breadth of view and common sense. Legal minds have devised elaborate documents—they might almost be called rituals—to cover some of the simple transactions of every-day business. If an attempt is made to apply this ultra-legalistic treatment and terminology to the more complex utility-industrial relationships, the resulting documents will be ponderous and forbidding. Negotiations will become increasingly difficult, and economic progress will be hampered. Contracts should, of course, be clear and reasonably complete, but they need not be picayune. In short, it may be assumed that responsible parties to arrangements of this sort will act in good faith.



SAN FRANCISCO steam plant of the Great Western Power Company was placed in operation last December with an initial capacity of 35,000 kw. It is designed for emergency stand-by service and equipped throughout with automatic controls. Crude oil is used, but the plant can be easily converted to the burning of natural gas

STEAM AND HYDRO PLANTS TYPICAL OF



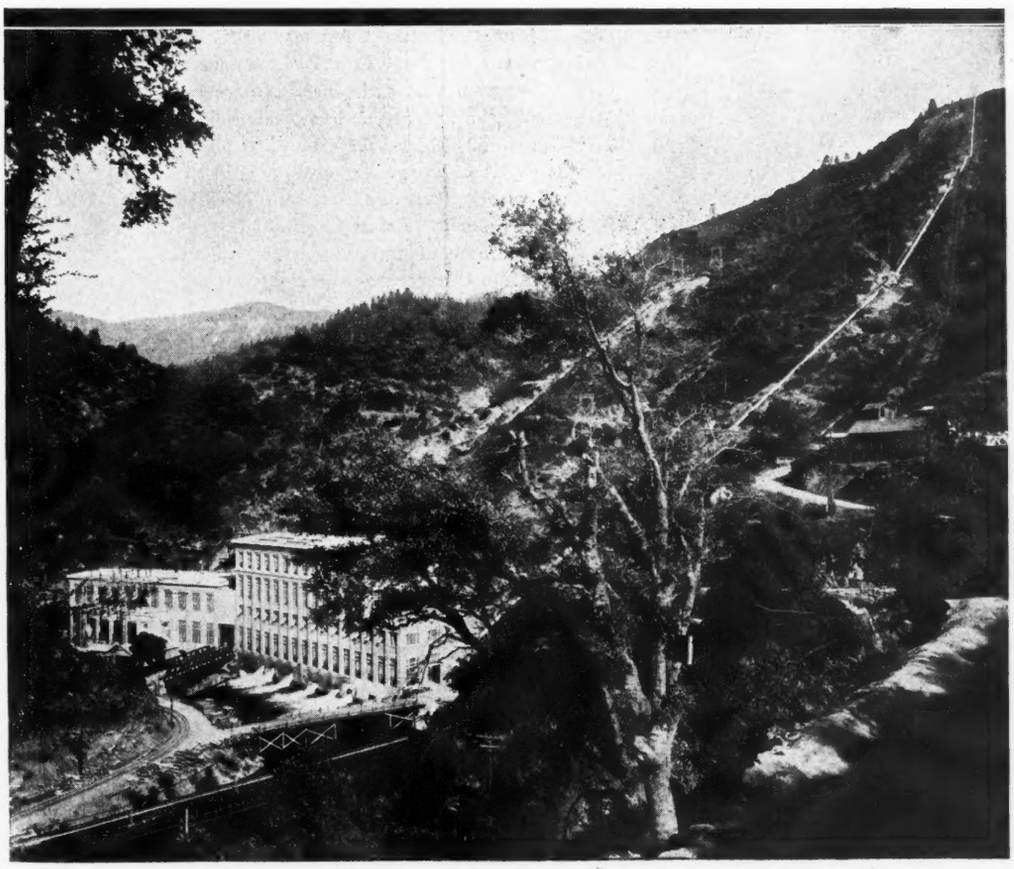
CONSTRUCTION is progressing rapidly on Diablo Dam of the City of Seattle's Skagit River power development. This dam, 388 ft. high, will impound 80,000 acre-feet of water and provide storage for the Diablo and Gorge power houses, ½ mile and 7½ miles, respectively, downstream. Scheduled for completion in September, 1930, the dam now affords partial storage for the Gorge plant, which has three 30,000-kw. units installed

DIABLO PLANT, for which contracts have been let, will be completed in 1931 with two 60,000-kw. units. Both plants will be doubled in capacity later when Ruby dam, 8 miles downstream and 520 ft. high, gives 3,000,000 acre-feet storage capacity. Then the three plants will provide 1,120,000 hp. on a 40 per cent load factor

PACIFIC COAST plants present a wide variety of the latest developments in central station design. In California with its enormous available supplies of fuel oil and natural gas the trend is toward more and larger steam stations, while further north vast water-power resources are rapidly being developed. On their visit to the convention in San Francisco, N.E.L.A. members may see for themselves the West's achievements in the field of power

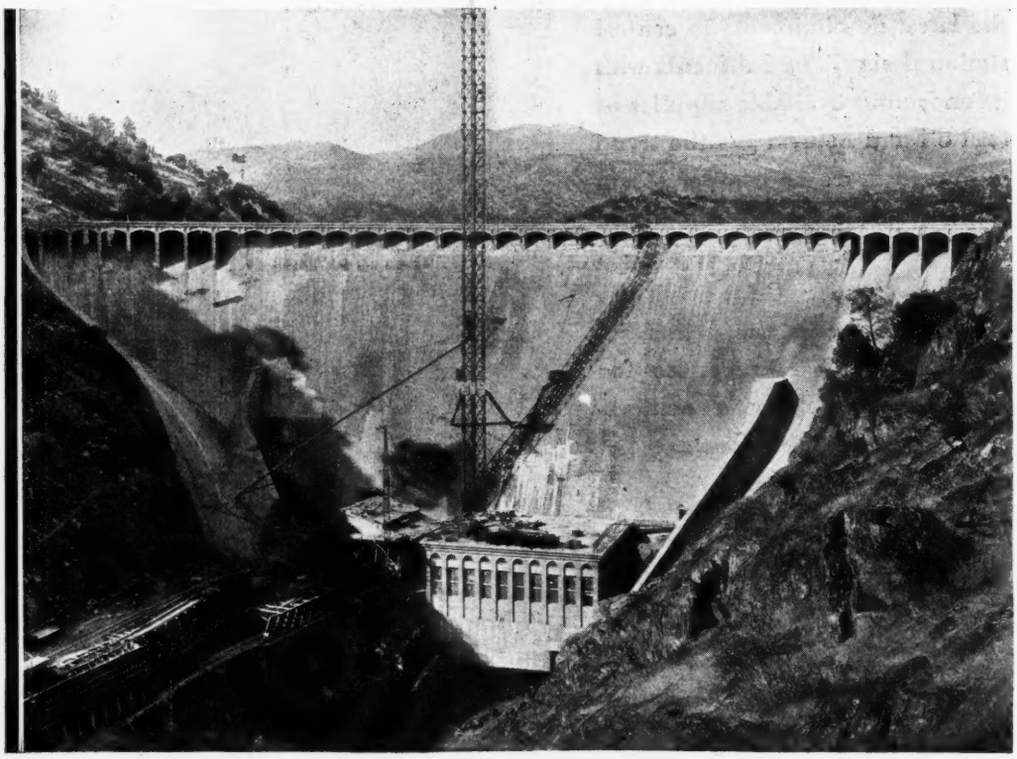
PROGRESS ON PACIFIC COAST

TWO 20,000-kva. generators in Cushman hydro-electric plant No. 1, located on the Skokomish River. The city of Tacoma is now building Cushman plant No. 2 with an initial installation of two 30,000-kva. units, the first of which will be in operation in the late fall. A 25,000-kw. steam plant in Tacoma is also under construction



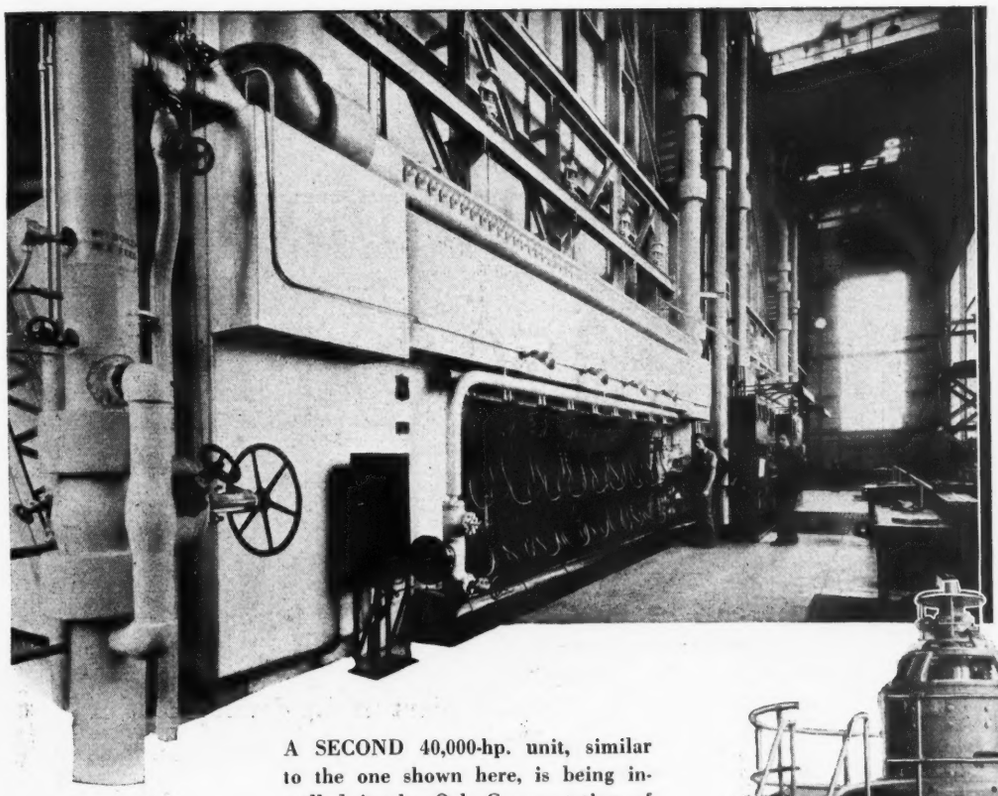
THE Southern California Edison Company's Big Creek plant No. 2 with its recent addition No. 2A. Power house No. 2A, the lower building at the left, contains two 62,300-hp., 2,418-ft. head impulse units, which are the largest and highest head turbines on the company's system

Pacific Coast Plants . . .

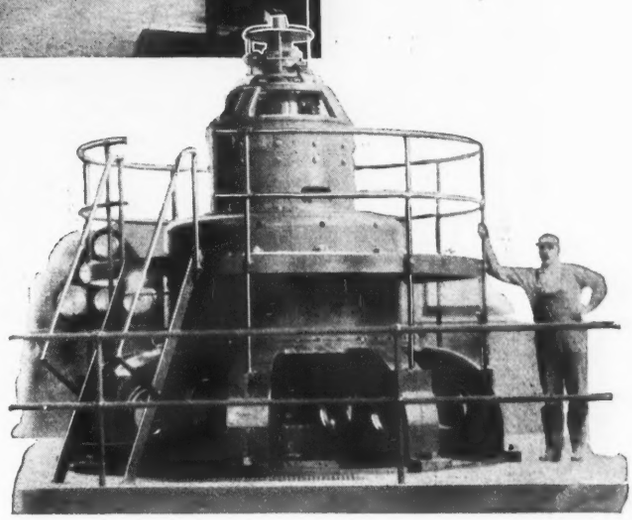


EXCHEQUER PLANT of the Merced Irrigation District is an interesting example of the combination of power development with flood control and irrigation. Two 24,500-hp. turbines are installed in the power house at the base of the dam

FOUNDATIONS for No. 1 turbine unit being installed by the Pacific Gas & Electric Company at its Station A, San Francisco, under a program that calls for reconstruction of the plant and installation of two 50,000-kw., 1,250-lb., 750-deg. F. vertical cross-compound turbine-generators, three boilers, and auxiliary equipment. Below is one of the new turbines, of unique design, on test at the Schenectady works of the General Electric Company



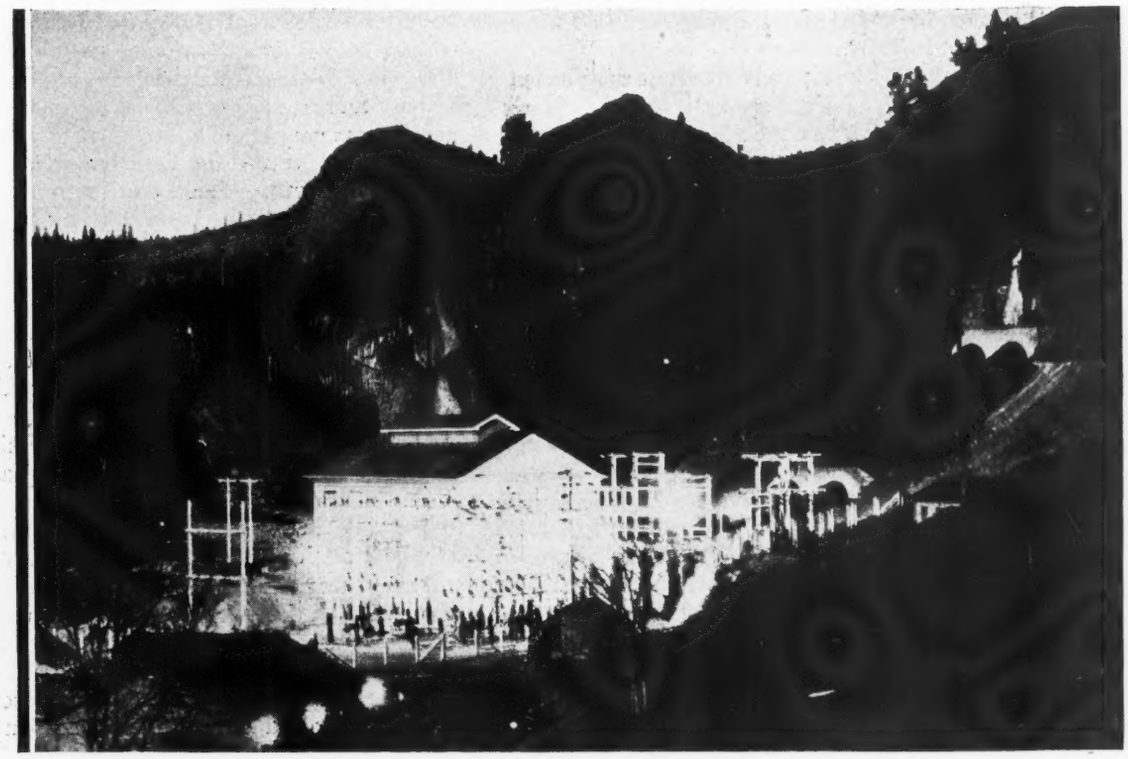
BOILER ROOM of the Puget Sound Power & Light Company's Shuffleton plant, where the first 50,000-hp. unit has been in continuous operation since its completion last September. During that time construction work has been progressing on a second 50,000-hp. unit



A SECOND 40,000-hp. unit, similar to the one shown here, is being installed in the Oak Grove station of the Portland Power & Light Company. These two units are the highest head (960 ft.) reaction turbines in the country

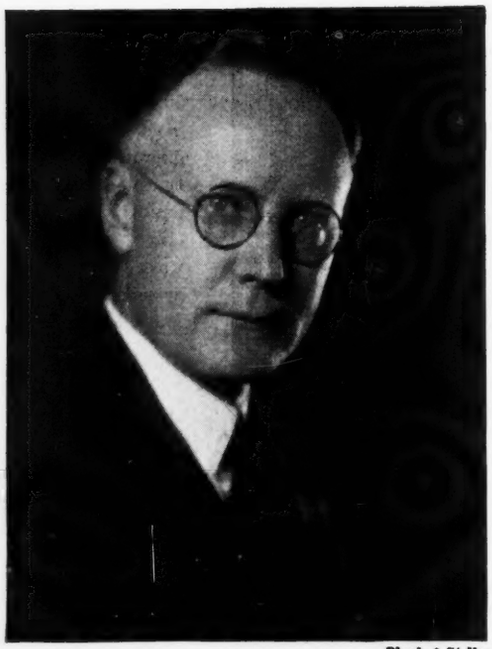
▼

COPCO No. 2 station in the California Oregon Power Company's system has a principal dam 207 ft. long and 35 ft. high. Generating equipment consists of two units with a total capacity of 24,000 kva.



MOKELUMNE PROJECT

TO DEVELOP 170,000 HP.



Blank & Stoller

By A. H. MARKWART
Vice-President
Pacific Gas & Electric Company[1]

The first plant in the development of the Mokelumne River, California, is at Salt Springs, where the largest rock fill dam is now under construction. The power house at this site will eventually contain 43,500 hp. in two units

IN 1911 the installed capacity of the Pacific Gas & Electric Company consisted of 145,000 kva. of hydro and 60,000 kva. of steam installation. By the end of 1929 the installation had grown to 502,000 kva. of hydro and 205,000 kva. of steam. The generated energy increased from 503,000,000 kw.-hr. by hydro plants and 112,000,000 kw.-hr. by steam plants in 1911, to 1,708,-100,000 kw.-hr. by hydro plants and 589,600,000 kw.-hr. by steam plants in 1929.

It is evident that with relatively steady annual increase in load, new power supplies must be brought in at regular intervals. Likewise, as the magnitude of the total load increases, the annual increments of additional supply increase. While at the present time additional supplies of energy to the order of 200,000,000 kw.-hr. a year are required, the average requirement over a period of five years will be approximately 250,000,000 kw.-hr. a year. Peak growth of power for the next five years will average 45,000 to 50,000 kw.-hr. annually.

The Mokelumne River project, when completed, in 1934, will have an installed capacity of 171,000 kva.: 71,000 kva. to come in the summer of 1931, 60,000 kva. in 1933, and 40,000 kva. in 1935. This stream, although perennial, is extremely flashy, requiring large amounts of storage for comprehensive development. The present Electra plant, constructed in 1902 and enlarged in 1907, develops only a small part of the average annual stream flow. Flow is regulated by several small reservoirs, chosen originally because they were inexpensive to construct; and the portion of the river utilized was that in which the river gradient is greatest.

Mokelumne River heads on the crest of the Sierra and flows in a southwesterly direction to join the San Joaquin River at its delta. The drainage basin lies slightly north of east of San Francisco with its center somewhat over 100 miles distant from that city. The basin is unusual among Sierra drainage basins, because of its relative narrowness, maximum width north and south being about 12 miles. The stream has three major forks, north, middle, and south. Middle and south forks come together a few miles above the point where they enter the north fork, and drain an area much lower in elevation than the north fork. The latter is by far the largest and most important, yielding about 80 per cent of the total runoff of the main stream. Its principal tributaries are Bear River, Cold Creek, and Blue Creek. The relatively precipitous drops of Cold Creek and Bear River make them susceptible to power development. The gradient of the main fork is steep for the upper 20 miles but is only moderate for the next 40 miles, the grade being about 65 ft. to the mile in the second 20-mile stretch and 80 ft. to the mile in the next 20 miles. It is in the second 20-mile stretch of river that the development begins.

An existing development heads about 40 miles west of the crest of the Sierra. Two canals with a total capacity of 210 sec.-ft. develop about 1,640 ft. of the fall in the river in the 20 miles to Electra. The summer flow is supported by storage in five small reservoirs, four of which, Upper and Lower Blue Lakes, and Meadow and

[1]Mr. Markwart became associated with the Pacific Gas & Electric Company in 1920, and is now vice-president in charge of engineering. He is a member of the American Society of Civil Engineers.

Twin Lakes, are old glacial basins located just below the crest of the Sierra, while the fifth is on Bear River. Total capacity of these reservoirs is 25,338 acre-feet.

Average seasonal stream flow of the north fork of the Mokelumne River above the diversion to the Electra development is 818 sec.-ft., varying from a maximum of 1,660 in one season to a minimum of 250 sec.-ft. in the lowest season of record. Of this stream flow the project will utilize, by means of storage and a conduit with diversion capacity of 575 sec.-ft., an average annual diversion of close to 550 sec.-ft., or about 70 per cent of the total flow available.

In contrast with the existing development, which utilizes about 25 per cent of the average stream flow, the proposed development contemplates the construction of additional storage of about 173,400 acre-feet, making a total of about 199,000 acre-feet. Total head to be developed on the north fork is 3,362 ft., against about 1,640 ft. at present. In addition, about 2,100 ft. of head between Bear River and the north fork is to be developed.

Maximum annual output is estimated at 1,038,000,000 kw.-hr., this being the yield of energy for twelve consecutive months of the 23-year period that has the greatest total water supply; the minimum annual output at 489,000,000 kw.-hr., this being the yield of energy for twelve consecutive months of the period that has the lowest total water supply; and the average annual output at 913,000,000 kw.-hr. Thus the minimum output is 47 per cent, and the average 88 per cent, of the maximum output, or yield, of the year of abundant water supply.

To make the output usable on all years it is necessary to employ steam plants to fill the deficiency in hydro supply when the output of energy is less than maximum. It is also necessary, in the interest of economy, to load-factor the hydro higher than the system load, which has a load factor of about 60 per cent, by pulling 30 per cent to 40 per cent of the system peak with steam plants. Thus the load that is appropriate for the Mokelumne development will be somewhat greater than its peaking capacity. Allowing for transmission losses, the system load into which the 1,038,000,000 kw.-hr. per annum from this development will fit best is one of about 1,093,000,000 kw.-hr. at the load center, which would correspond to a peak there of about 208,000 kilowatts.

Steam required to accommodate a system peak of this size is about 70,000 kw., whereas steam required to answer the hydro deficiency on the year when the output is estimated at 489,000,000 kw.-hr. at the hydro plant is 84,000 kw., which amount will provide some reserve capacity on all but the driest years. It is estimated that the average energy to be supplied by steam plants employed on the system peak and to make up the deficiencies in hydro energy on years when the yield is less than the maximum will average approximately 217,000,000 kw.-hr. per year. On years of great hydro deficiency the system peak will be carried by hydro, which is substantially unreduced in peaking capacity, and steam plants will be used on the base of the load on a high load factor to supply hydro deficiency in base-load energy.

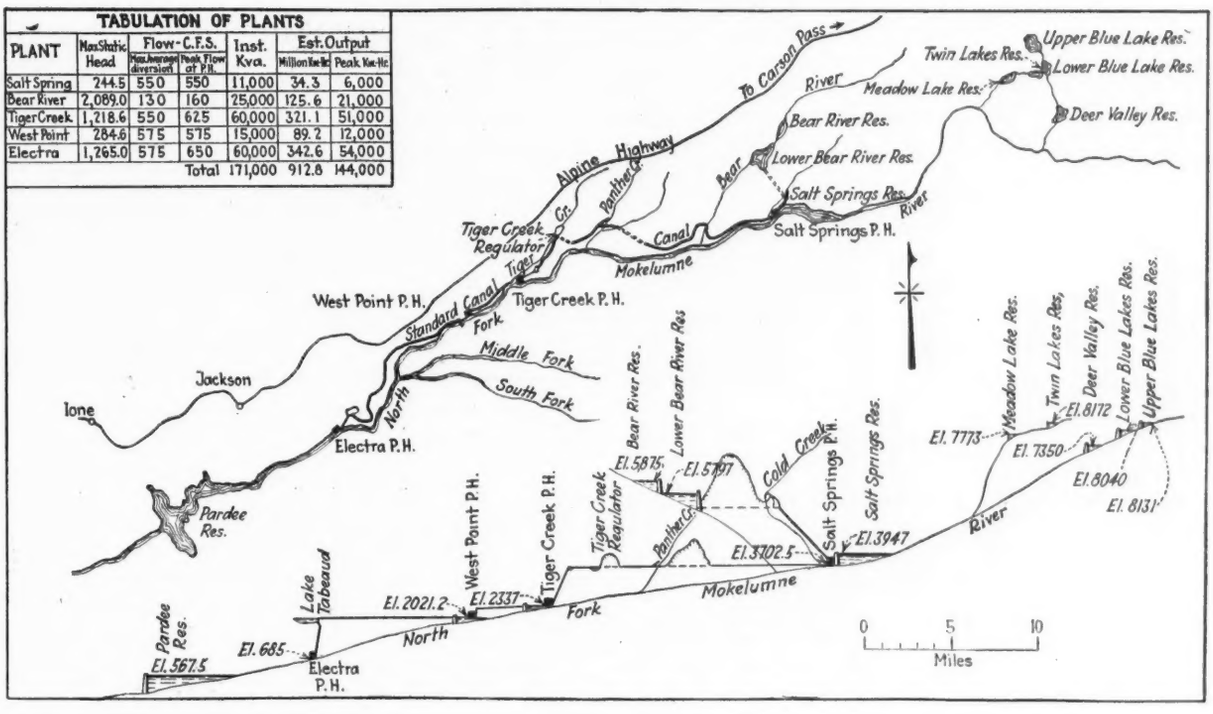
With the present Electra development there is about 8,000 kw. of installed steam capacity required to supply the dry year deficiency in kilowatt-hours, so that the additional steam installation required for this development will be 76,000 kw., which amount is now being provided at Station A, San Francisco, through the installation of two units having a rated capacity of 50,000 kw. each. The actual capacity of the two is about 120,000 kw.; 27,000 kw. of obsolete capacity is being removed, leaving a net increase in rated capacity of 73,000 kw. and an actual capacity of about 93,000 kw. This will provide sufficient support for stand-by against line failure, and ample capacity for meeting the dry-year hydro energy deficiency for the entire Mokelumne development.

An advantage of completing the steam plant at this time is that the growth in load may be carried on steam until the completion, in the summer of 1931, of the first unit of the hydro project, at Tiger Creek. Estimated average annual output for this plant is 321,000,000 kw.-hr., about 50 per cent in excess of probable annual

The five plants of the Mokelumne project develop a total head of 5,100 ft. and drain 356 square miles

TABULATION OF PLANTS

PLANT	Max. Static Head	Flow - C.F.S. Max. average diversion	Flow - C.F.S. Peak Flow at P.H.	Inst. Kva.	Est. Output Million Kw.-Hr.	Est. Output Peak Kw.-Hr.
Salt Spring	244.5	550	550	11,000	34.3	6,000
Bear River	2,089.0	130	160	25,000	125.6	21,000
Tiger Creek	1,218.6	550	625	60,000	321.1	51,000
West Point	284.6	575	575	15,000	89.2	12,000
Electra	1,265.0	575	650	60,000	342.6	54,000
			Total	171,000	912.8	144,000



increase in load. By building up load on steam during 1930 and 1931 it will be possible to absorb the output of Tiger Creek from the date of its completion, by backing down the steam. Similar practice will obtain with the schedule of completion of other units of the development, so that when the last unit is completed, in 1934, its energy will at once be usable in the system load.

The first unit of the project, known as the Salt Springs-Tiger Creek development, is now under construction. The plans call for a reservoir at Salt Springs with a capacity of 130,000 acre-feet and a power house at the base of the dam developing the created head. This water will then be discharged into the conduit to Tiger Creek power house, which is situated about twenty miles downstream.

Salt Springs damsite is located in the gorge of the Mokelumne River, about a mile above the two natural landmarks, Calaveras Bald Rock on the south side of the gorge and Amador Bald Rock on the north side. These granite domes rise over 3,000 ft. above the stream bed. At present the company's construction forces are actively engaged in building the dam, which was started in 1929. When complete, in 1931, the structure will be the largest rock-fill dam in the world. It will rise 328 ft. in height above the stream bed, with a crest length of 1,300 ft., and will contain about 3,000,000 cu.yd. of material. The section has a downstream slope of 1.4 to 1 and an upstream slope of 1.3 to 1. It is constructed mainly of loose granite rock, quarried on the sides of the gorge adjacent to the site. The upstream slope of the rock fill is faced with derrick-placed rock 15 ft. in thickness. This placed rock forms a foundation for the outer facing of reinforced concrete which covers the entire upstream slope, varying in thickness from 12 in. at the top to 36 in. at the bottom. The concrete face is poured in slabs about 60 ft. square, separated by expansion joints made water-tight by sheet copper seals.

A spillway of the side-channel type is being excavated on the south wall of the gorge. The crest length will be 625 ft., giving a capacity of 48,000 sec.-ft. with 8 ft. of freeboard.

The reservoir thus created will permit storage of 130,000 acre-feet. It will submerge a flat portion of the gorge extending about 4 miles above the damsite and will flood about 930 acres when full.

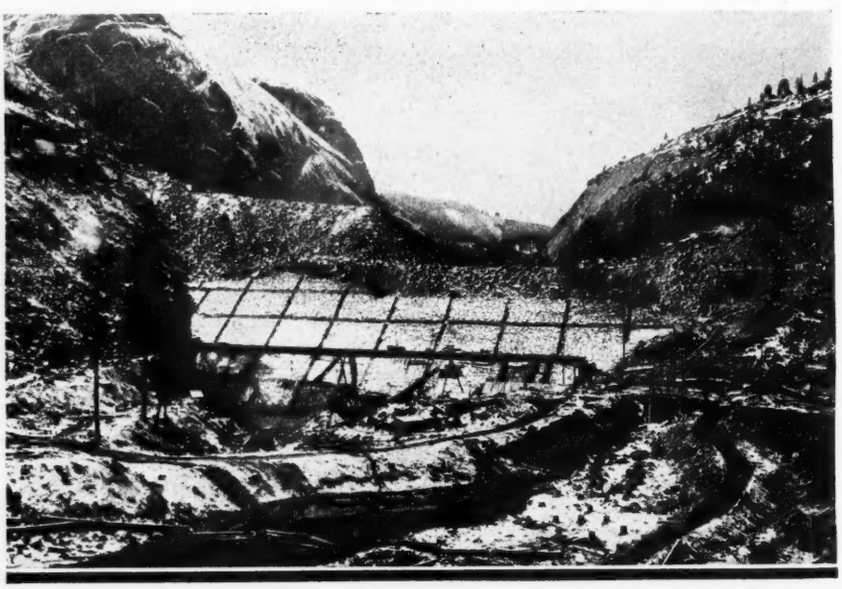
Outlet works will consist of a concrete-lined tunnel 19 ft. in diameter and 920 ft. long. The lower end of the tunnel will be plugged with concrete, with two steel pipes 10 ft. in diameter inserted, and 10 ft. 9 in. butterfly shut-off valves provided. These pipes will extend to the river bank and each be closed by a 78-in. diameter butterfly valve designed for free discharge. The valves will permit of unwatering the reservoir at a fairly rapid rate in case of emergency. Maximum discharge capacity of both valves is 5,200 sec.-ft., or 10,000 acre-feet per day. Suitable trash-rack structures will be constructed at the upper end of the tunnel. The large section of outlet tunnel is to give proper capacity for passing floods during the period of construction, an important consideration with this type of dam.

An 8-ft. diameter branch from one of the outlet pipes will form the penstock for the Salt Springs power house, a few hundred feet downstream from the dam. A 90-in. butterfly valve will be provided on this pipe at the power house. A branch from the other outlet pipe, equipped with a 72-in. butterfly valve, will extend to a 54-in. needle valve in which is incorporated an energy absorber known as a "through baffle," which will discharge into the power house tailrace. This bypass line is necessary to divert water from the reservoir into the Tiger Creek conduit, which heads the tailrace, when the Salt Springs unit is shut down, or when it is operating under reduced head.

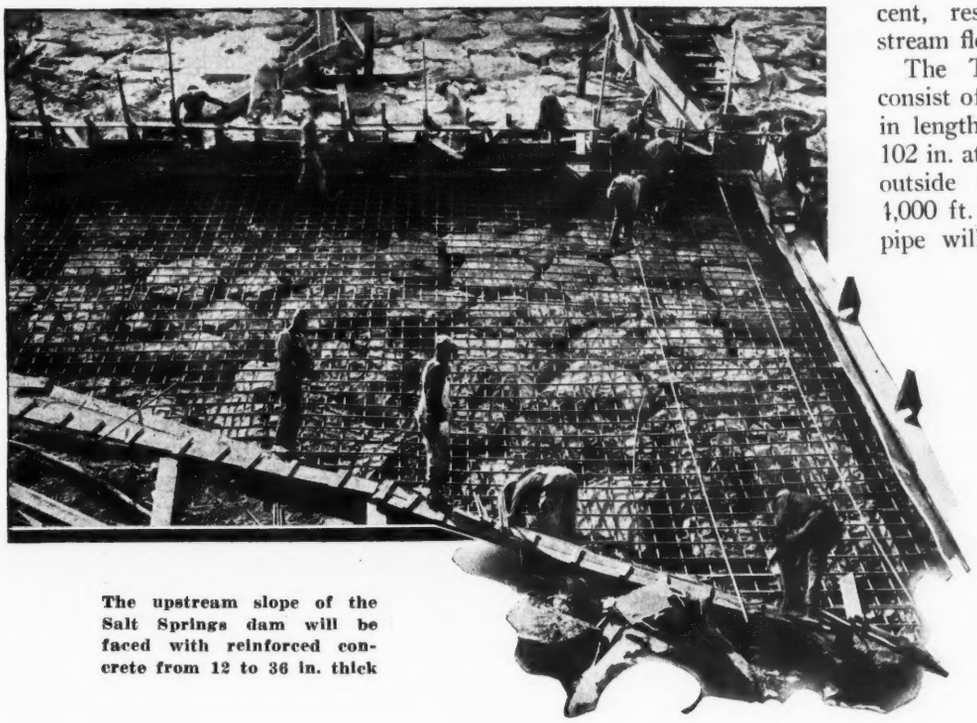
A reinforced concrete and steel building will house the generating equipment. This will consist of a single vertical 11,000-kva. generator, direct-connected to a 13,500-hp. vertical turbine. The turbine is designed to pass 550 sec.-ft. between heads of 240 ft. and 175 ft. The unit will operate at 300 r.p.m., with a generator voltage of 11,000.

Space will be provided in the power house for future installation of an impulse unit to be operated under about 2,000-ft. head with water from Bear River and Cold Creek. This unit will probably consist of a 25,000-kva. horizontal generator, direct-connected to a 30,000-hp. impulse wheel. The wheel will be equipped with a deflecting nozzle discharging into an energy absorber in order to permit the tail water to be diverted into the Tiger Creek conduit.

Water discharged from Salt Springs power house will be diverted from the tail canal into Tiger Creek conduit, of 550 sec.-ft. capacity. This conduit will be 17.3 miles in length, terminating in a regulating reservoir on Tiger Creek. From the regulator a conduit of 625 sec.-ft. will extend 2.6 miles to a small forebay at the head of the penstock to Tiger Creek power house. The conduit will be composed chiefly of reinforced concrete flume, with a water section of approximately 84 sq.ft. and a water depth of 6 ft. Grade of the portion from the intake to the regulator will be 0.8 ft. per 1,000 ft., and grade of the portion between the regulator and the forebay 1.0 ft. per 1,000 ft. Part of the flume will be elevated, but, in the main, it will be of the bench type. In addition to the flume there will be two steel siphons, 93 in. in diameter.



The rock fill dam at Salt Springs will be 328 ft. high and will form a reservoir of 130,000 acre-feet capacity



The upstream slope of the Salt Springs dam will be faced with reinforced concrete from 12 to 36 in. thick

totaling in length 0.23 mile, and 2.5 miles of tunnel with a section 10 ft. wide x 11.3 ft. high on a grade of 3.5 ft. per 1,000 ft.

The regulator reservoir will be formed by construction of a concrete arch dam about 100 ft. high on Tiger Creek. The upper 14 ft. of the reservoir will provide about 175 acre-feet capacity. This capacity will be sufficient to permit peaking the Tiger Creek plant for 20 hr. each day when full diversion is being made at the head of the Tiger Creek conduit.

The forebay will be formed by excavating a large section around the contour of a knoll on the ridge above Tiger Creek power house. It is estimated that about 200,000 cu.yd. of excavation will be required to provide 35 acre-feet of capacity. The capacity is needed at this point in order that instantaneous peaks may be handled at all times. About 30 min. is required for water released at the regulator to reach the forebay. The available capacity will be sufficient to provide peaking flow during this interval. Under this condition of operation, which is of the nature of emergency peaking, water will be released from the regulator at the same time that draft from the forebay commences. Under normal operating conditions, water will be released from the regulator in anticipation of peak requirements. The peak load will be pulled at the time this water reaches the forebay. With this method there will be no appreciable drawdown of the forebay.

Between Salt Springs power house and Tiger Creek regulator the conduit crosses a number of more or less important tributaries, Cold Creek, Bear River, Beaver Creek, East Panther Creek, and West Panther Creek, from which diversions are to be made. The drainage area above Salt Springs reservoir is 160 square miles. Total drainage area tributary to the conduit is 262 square miles. Estimated average seasonal stream-flow from the area tributary to Salt Springs reservoir is 448 sec.-ft., while that tributary to Tiger Creek conduit is 685 sec.-ft. Average flow through Salt Springs plant is 354 sec.-ft., and that diverted by Tiger Creek conduit 490 sec.-ft., representing a development of 79 per cent and 72 per cent, respectively, of the average stream flow available to these plants.

The Tiger Creek penstock will consist of a single steel pipe 4,750 ft. in length, varying in diameter from 102 in. at the top to 72 in. at the "Y" outside the power house. About 4,000 ft. of the upper portion of the pipe will be of riveted steel, with rivets countersunk on the inside of the pipe. The lower 740 ft. will be of seamless pipe. The pipe will branch at the "Y" into two 52-in. diameter lines, and again into four 36-in. diameter lines, a separate line leaving to each of four impulse wheels of two double-overhung units in the power house.

The power house building will be of structural steel and concrete. The installation will consist of two double-overhung impulse wheel units of 36,000 hp. each, direct connected to 30,000-kva. generators. The wheels are designed to deliver 18,000 hp. each when operated at 225 r.p.m. under a net effective head of 1,190 ft. Generators will operate at 11 kv.

To re-regulate the discharge from Tiger Creek plant for re-diversion to the next lower plant, an afterbay is to be provided. This will be formed by the construction of a concrete arch dam, about 100 ft. in height, in the river some two miles below the plant. The dam will create a reservoir with a flooded area of about 100 acres. The top 3 ft. of this pond, with a capacity of 300 acre-feet, will be used to re-regulate the Tiger Creek peaks as well as some of the irregularities in the natural runoff tributary, to the lower plant, which are not controlled by storage on the system.

Tiger Creek plant is being designed to control the output from the Salt Springs and Bear River units, as well as the Tiger Creek units. The transmission line from Salt Springs power house will terminate in the Tiger Creek substation bus. Two banks of transformers with one spare are to be installed. These transformers are provided with combined two-winding and auto-transformer windings. The transformer banks will have a capacity of 60,000 kva. each—30,000 kva. for one Tiger Creek unit and 30,000 kva. from Salt Springs. Each bank is capable of carrying the normal Salt Springs output, as well as the output from one Tiger Creek unit.

Following completion of the Salt Springs-Tiger Creek development, it is planned to commence work immediately on the second unit of the development, involving reconstruction of Electra. The power house will occupy a site immediately adjacent to the present plant, but the diversion conduit will be relocated. The present plant is supplied by two canals, separated about 200 ft. in elevation where they join the penstocks. The upper canal has a capacity of about 135 sec.ft., and the lower 65 sec.-ft. The present upper canal has no forebay facilities, while the lower canal terminates in Tabeaud Reservoir, with a capacity of 1,158 acre-feet. Both canals have grades of 2.5 ft. per 1,000 ft. for flumes, and 1.5 ft. per 1,000 ft. for ditch sections. These grades are exces-

sive for the enlarged capacity now contemplated. The present plan for reconstructing this unit of the project is to build a new conduit below the two existing canals, beginning at the high water level of Tabeaud Reservoir and rising on a grade of 0.8 ft. per 1,000, until the grade line intersects the river gradient. This new conduit will be about 16 miles long, intersecting the river in the vicinity of the West Point Road crossing and about 4 miles below Tiger Creek afterbay dam. It will have a capacity of 575 sec.-ft. An advantage of this plan is that existing canals and power house may be operated without interference during construction of the conduit.

The new plant will develop a maximum static head of 1,275 ft. Tentative plans call for an installation of 60,000 kva. The plant will tie in to the Tiger Creek-Newark transmission line.

The next unit to be constructed will develop the head between the Tiger Creek afterbay and the new Electra intake, and will be called the West Point plant. A diversion conduit will start from Tiger Creek afterbay about 3 ft. from the top of the dam and will follow, roughly, the location of the present upper canal supplying Electra for about 4 miles, where it will join the penstock. No forebay facilities being available, the plant will be designed to operate at 100 per cent load factor. Static head will be about 285 ft., and maximum flow 575 sec.-ft. An installation of 15,000 kva. is planned. Energy from this plant is to be used to supply demands now served by the present Electra plant. A 60-kv. transmission line on wood poles will be constructed to tie into the existing Electra transmission.

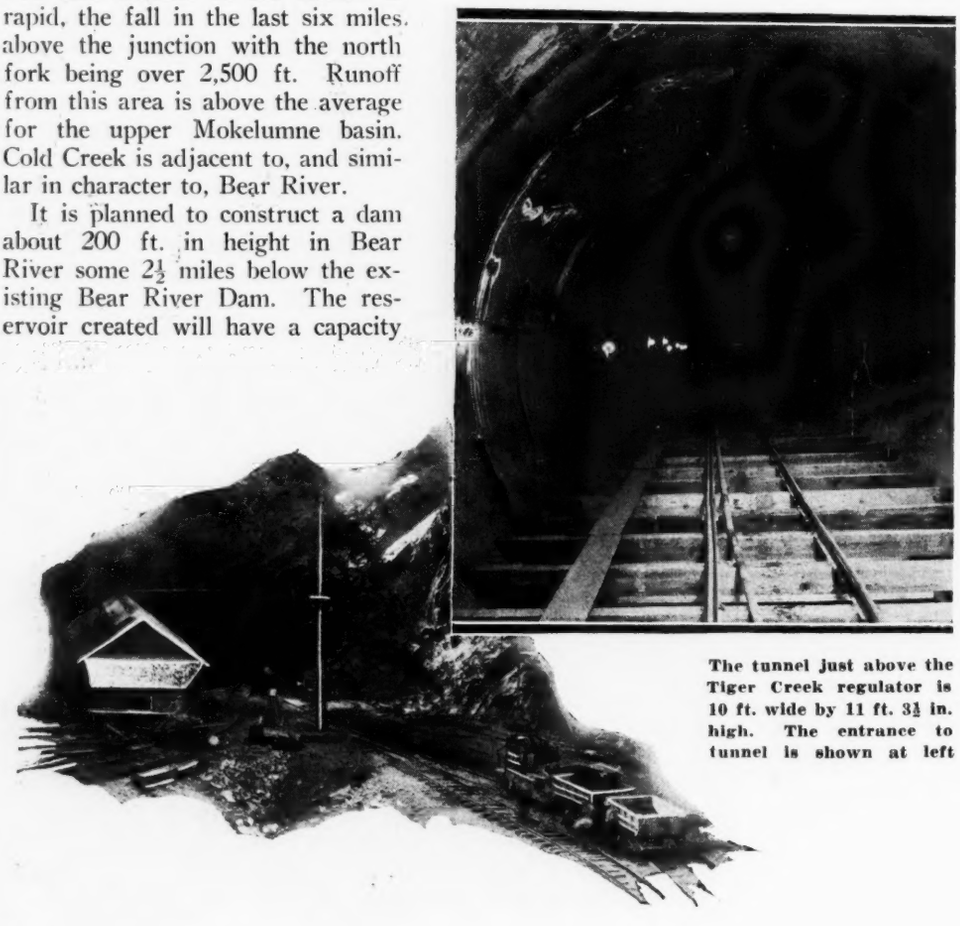
The last unit to be constructed will be known as the Bear River development. Bear River is one of the principal tributaries of the north fork of the Mokelumne. The drainage basin is high in elevation and descent of the stream is rapid, the fall in the last six miles above the junction with the north fork being over 2,500 ft. Runoff from this area is above the average for the upper Mokelumne basin. Cold Creek is adjacent to, and similar in character to, Bear River.

It is planned to construct a dam about 200 ft. in height in Bear River some 2½ miles below the existing Bear River Dam. The reservoir created will have a capacity of 54,000 acre-feet. A tunnel about 2½ miles in length from the new reservoir will reach the ridge between Cold Creek and the north fork of the Mokelumne, where it will connect with a penstock lead to Salt Springs power house. The junction of penstock and tunnel is below the center of the ridge, and at this point a surge chamber will be excavated to pierce the ridge. A flood-diversion conduit leading from Cold Creek will terminate at the surge chamber. Elevation at this point is higher than high water in Bear River Reservoir. By means of this arrangement the area above the diversion point on Cold Creek is made tributary to the reservoir on Bear River. No storage is provided on Cold Creek. Water diverted from Cold Creek is partly used through the power house and partly backed up the pressure tunnel to the reservoir on Bear River. Water from these sources may be wasted into the north fork above the Salt Springs dam. The arrangement is ideal from the standpoint of ease in using runoff from the different sources. A total head of 2,100 ft. is developed by this plant.

Additional storage on the upper watershed is to be provided at Deer Valley Reservoir. A rock-fill dam about 90 ft. high on Deer Creek in the upper watershed will create a capacity of 9,400 acre-feet. When this storage is completed, total new storage in the entire development will be 173,400 acre-feet, and total on the stream above the development about 200,000 acre-feet.

Total cost of the Mokelumne development as outlined, including transmissions and increased capacity at Newark substation, is of the order of $39,000,000, to be expended during the next five years. To this is to be added approximately $6,700,000 for the first 100,000 kw. of installed steam capacity at Station A, San Francisco, with prospect of substantially the same expenditure for another 100,000-kw. block during the next few years.

Design of the project is being made by the company's department of engineering. Structural and hydraulic features are being handled by the division of civil engineering, of which I. C. Steele is chief engineer, and Walter Dreyer principal assistant. Hydraulic equipment and electrical work is under charge of J. P. Jollyman as chief of the division of hydro-electric and transmission engineering, with E. A. Crellin as his assistant. Construction work in the field is being performed by company forces under O. W. Peterson, engineer of general construction, with P. I. Kurtz and G. M. Wehrle as superintendents of construction.

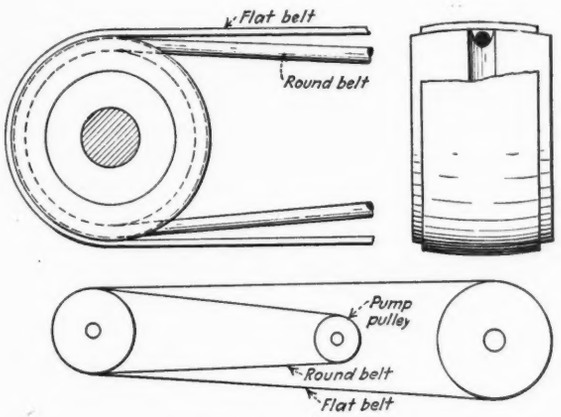


The tunnel just above the Tiger Creek regulator is 10 ft. wide by 11 ft. 3¼ in. high. The entrance to tunnel is shown at left

. . . RIGHT OUT OF THE PLANT . . .

Double Belt Drive From One Pulley

I HAD occasion to use a small belt-driven pump in a temporary position that offered no convenient means for driving it. However, there was a solidly built pulley on a machine just where I needed it, so I took off the pulley and cut a V-groove in the center of it deep enough



Arrangement of round and flat belt drive from same pulley

to take the round belt of the pump. I then mounted the pump with the pulley between the machine driving belt and slipped the round belt in place.

It worked ideally for the short time required, but I would hesitate to recommend it as a permanent drive, because of the danger incurred if the small belt should break after continued use. H. MOORE.

Hamilton, Ohio.

Relief Valves on Hot-Water Tanks

I SHOULD like to add to the discussions on "Relief Valves on Hot-Water Tanks" which appeared in the April 8 number. I have given this subject a good deal of attention and could cite scores of instances of failure of relief valves to function.

I have not found any satisfactory method of protecting water heaters against overpressure, with the consequent danger of rupture or explosion. It would not seem that the situation justifies the inspection given high-pressure boilers, but to secure an equal degree of prevention against explosion or rupture more frequent inspection is required than with high-pressure boilers, because of the corrosive action of most waters on the safety devices.

A majority of these installations are in charge of people ignorant of their possibilities of destruction and who know nothing of their protective devices. The problem is to make them as foolproof as possible.

Hot-water tanks are generally protected by spring-loaded relief valves, but I prefer a weighted-lever relief valve. When any type of spring-loaded valve leaks, many plumbers will screw the adjusting nut down until it stops leaking, regardless of the fact that they may be setting the valve at many times the bursting pressure of the tank or heater.

Most spring-loaded valves have no lever by which they may be checked occasionally to see that the connections are open. Choking of connections with scale, etc., is a common cause of failure of such valves to function. To flush the valve, pressure adjustment must be disturbed, with consequent necessity of resetting, by guess, unless one has a test pump and gage.

It has been my experience that the manufacturer's setting of such valves is unreliable. I have seen ones that had not been tampered with, yet would not open under twice the pressure stamped on them.

With a weighted-lever valve it is easy to raise the lever and flush the connections, to take it apart and regrind the seat or renew the disk if necessary, and to re-install and reset the parts correctly without necessity of pump or gage. The setting can be checked instantly. It is so easily done that there is no temptation to guess. It is common experience with devices of this sort that if they are too complicated the user will put them out of commission just like the plumber "chokes" the spring-loaded valve so that he can forget about it.

Manufacturers claim that weighted-lever valves must be set about 20 per cent higher than the pressure at which they are desired to open to prevent leakage at operating pressure. Other advantages of this type of valve, however, outweigh such objections in most cases. For instance, with a working pressure of 50 lb. and a desired opening of the relief valve at 60 lb., an actual opening at 72 lb. would not ordinarily make much difference.

After observing hundreds of installations, it is my opinion that in most cases failure is prevented by leakage past the check valve on the supply line and not by the operation of the relief valve. I frequently find tanks in regular use, fired by "fits and starts" and often overheated, yet the relief valve has not opened in months or years. Check valves are usually installed on the supply line to the tank, but not on the building supply. Even if leather-faced check valves are on the building supply, overpressure, when once past the check valve on the tank supply, will relieve itself through leaking faucets, ball cocks, etc. Probably most ball cocks are so designed that they would open on pressures much less than would cause failure of the tank or heater. Many buildings have a pressure-reducing valve on the main supply, and where they are in good condition, which is seldom, they have the effect of a check valve. Probably 75 per cent of hot-water-heating outfits have neither relief valve nor check valve on the main supply or on the connection to the

tank. Overpressure relieves itself by backing up into the supply main.

I have advocated connecting the circulating pipes between the heater and the tank (See Fig. 1) so that about 25 per cent of the tank volume is below the circulating connection and will therefore remain comparatively cold. No check valves will be used on the house service or tank supply. This reservoir of relatively cold water at the bottom of the tank will more than take care of expansion of the water from its lowest to highest temperature.

If heating is continued to production of steam, this volume is, of course, not sufficient, and hot water is backed out of the tank into the piping. This is ordinarily impossible with steam-heated tanks or those heated by circulating heaters, because water pressure is generally higher than that of the heating medium, steam or water. In case of coal-fired heaters steam would not be produced unless the heater was disproportionately large compared to the tank, or was fired unusually hard. Regulators cannot be depended upon to prevent overheating with coal-fired heaters, because they are easily disengaged. Thermostats on gas-fired heaters are reliable and seem to be kept in working order without difficulty. Oil-fired heaters are not so susceptible to satisfactory regulation as gas heaters, but probably most of them are in larger sizes and have better supervision.

However, if all regulation fails the worst that can happen is a damaged water meter. I am not discussing here the possibility of explosion by cold water rushing into an overheated heater from which it has been forced

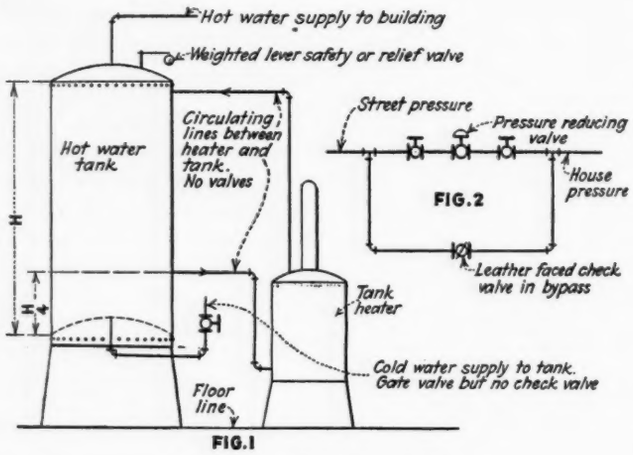


FIG.1

Tank and heater connections

by steam in the tank or drawn out by failure of the water supply. This seldom happens.

In cases where a pressure-reducing valve is used on the supply main I should install a leather-faced check valve in a bypass around the pressure-reducing valve (See Fig. 2), opening back into the high-pressure main so that the reducing valve would not prevent overpressure's relieving itself back into that main in the manner intended. Unlike the check usually installed in the feed to the tank, which is generally a brass disk valve, this leather-faced check on cold water is reliable.

Lastly, I should install a composition-seat, weighted-lever relief valve on the tank and undertake to keep it in operating condition. This to guard against the supply main or heater supply being cut off by closing of a valve; for every installation must have a service valve at least, which might be shut at the wrong time. However, with this arrangement dependence is placed on the relief valve for possible 1 per cent of safety, with the other 99 per cent absolute; rather than 100 per cent dependence on the relief valve, as is the case with check valves on a tank supply or water main.

In the foregoing it is assumed that the street pressure is lower than the safe maximum pressure, which is generally true. In the rare case where the street pressure is higher dependance must be put in the relief valve.

Chattanooga, Tenn. H. C. RUSSELL.

Lubricating Engine Cylinders When High-Temperature Steam Is Used

I HAVE read with interest the letters from readers in the April 29 number concerning the use of high-temperature steam and other factors in connection with uniflow engine operation. There should be no difficulty whatever in lubricating these engines with 300 lb. pressure and 100 deg. superheat, especially the poppet-valve type of engine.

We have lubricated locomotives having a piston speed probably in excess of that in question operating with steam at 240 lb. pressure and 450 deg. superheat, giving a total steam temperature of 850 deg. Some question might be raised about the advisability of too much superheat in the exhaust. However, that was not our problem.

With steam at 850 deg. total temperature, the piston-rod packings were burned out. Superheater units were removed until the steam temperature was reduced to around 680 to 710 deg. F. With a late cutoff the engine lubricated satisfactorily with steam at 680 deg., but not so good at 710 deg. However, with a short cutoff, say 40 per cent, the engine lubricated well with the steam at 710 deg. This is due to the temperature drop with the greater expansion. The cylinders and valves lubricated fairly well even at 850 deg. F., but the rods became dry owing to their constant exposure to the atmosphere at this high temperature.

We have no trouble lubricating high-speed passenger engines with a short cutoff (25 to 30 per cent) at 730 deg. with a 560-flash valve or cylinder oil. I should say that about 750 deg. is the limited with a 25 per cent cutoff, and about 680 deg. with a late (75 per cent) cutoff, for satisfactory lubrication with a good average quality of cylinder oil. W. P. LAMBERT,

Engineer, Sales Dept.,

New York, N. Y. Standard Oil Co. of New Jersey.

Power From Ice Water

UPON SEEING the letter by E. S. Smail in *Power*, April 29, it occurred to me that there was another objection to Mr. Barjot's plan of obtaining power from ice in the Far North which Mr. Smail had not mentioned. It is that a very considerable quantity of the hydrocarbon would become attached to the ice crystals and would thus be lost.

While this source of loss is not mentioned by Dr. Barjot either, I think it would be quite serious. Although the loss might be diminished by whirling the ice crystals in a centrifugal apparatus, this would so add to the complication and expense of running the plant that the net result would be still more unfavorable.

Cincinnati, Ohio. A. H. PUGH.

NEWS of the FIELD

Spot News

AFTER YEARS *of consideration a license for site No. 1 of the Flathead power project in Montana was granted May 19 to the Rocky Mountain Power Company by the Federal Power Commission. According to its terms, the company will pay the Indians, whose reservation includes the site, a total rental of $2,845,000 for 20 years, and starting with an initial installation of 50,000 hp., will ultimately develop the full 105,000 hp. No decision was reached as to a preliminary permit on the four other Flathead sites.*

PLANS *for the erection at Burlington, N. J., of a $50,000,000 steam plant with an ultimate capacity of 300,000 kw. were announced May 22 by the Public Service Corporation of New Jersey. The initial installation will include two 60,000-kw. turbine-generators.*

TO INCREASE *the efficiency of steam vessel inspection, 45 assistant inspectors and 16 clerks will be added to the Steamboat Inspection Service July 1, Secretary of Commerce Lamont announced last week. Distributed at the principal ports throughout the country, 22 of the new assistants will be boiler inspectors.*

BILLS *designed to give the department of public utilities certain supervision of holding companies have just been reported to the Massachusetts legislature by its committee on power and light. The measures provide regulation of payment for services rendered by holding companies, rate contracts, and the establishment and sale of municipal plants.*

CONSTRUCTION *of a power dam on the Osage River at Bagnell, Mo., by the Union Electric Light & Power Company has been halted by a decision of the circuit court holding the acquisition of certain public property at Linn Creek in Camden County illegal and void because the property was sold without the necessary two-thirds vote of the people of the county.*

Nearly 4,000 Expected at N.E.L.A. Meeting in San Francisco, Calif., June 16-20

Well-rounded business and entertainment program planned for largest gathering on Pacific Coast—Messages to be exchanged with World Power Conference.

MATTHEW S. SLOAN
President of the N.E.L.A.

WITH AN expected attendance of close to 4,000, the 53d annual convention of the National Electric Light Association, which will be held in San Francisco, Calif., from June 16 to 20, inclusive, promises to be the largest gathering of its kind ever held on the Pacific Coast. One of the world's greatest auditoriums, Civic Auditorium, will be the scene of the convention's eight business sessions and many of its interesting entertainment features.

The program will be well diversified, in that it will deal with specific problems of the several branches and departments of the industry as well as with the more general questions affecting the industry as a whole. Not only will there be talks by many of the industry's own outstanding men, but a number of leaders in other fields have accepted invitations to address the convention and present outside points of view that are certain to be of interest and value.

What promises to be a high point of both the convention and the World Power Conference in Berlin will take place on Wednesday, June 18, when messages will be exchanged between the two over a world-wide radio hook-up. The program will be broadcast in this country through the blue network of the National Broadcasting Company.

Monday, June 16, will be devoted to registration, committee meetings in the morning and the intergeographic division finals of the employees national public speaking contest in the afternoon, followed by the president's reception and ball in the evening. The first general session will open on Tuesday morning, President Sloan presiding, with an address of welcome by James Rolph, Jr., Mayor of San Francisco. Merle Thorpe, editor of *Nation's Business*, and Fred W. Sargent, president of the Chicago and Northwestern Railway Company, will be the guest speakers.

Simultaneous sessions of the accounting and engineering sections will be held in the afternoon. At the latter meeting Alex D. Bailey, chairman of the engineering national section, will preside. A. H. Markwart, vice-president of the Pacific Gas & Electric Company, will speak on "The Future of Water-Power Development in California"; A. H. Kehoe, electrical engineer with the United Electric Light & Power Company, will have "Trend of Costs" as his subject; and Herbert A. Barre, chief engineer of the Southern California Edison Company, will also speak.

At the second general session on Wednesday morning, A. W. Robertson, chairman of the Westinghouse Electric & Manufacturing Company, will discuss "The Commercial Day"; Edward N. Hurley, former chairman of the United States Shipping Board, will speak on "Government in Business"; and W. A. Jones, vice-president of the N.E.L.A., will foretell "The Future of the Electrical Industry." During this session an interchange of messages will take place between the convention in San Francisco and the World Power Conference in Berlin.

The commercial national section, with M. E. Sampsell chairman, will hold its session in the afternoon, at which reports of the lighting, power and merchandising bureaus will be heard. Martin J. Insull, president of the Middle West Utilities Company, will discuss "Load Building Opportunities Ahead of Us," and Gerard Swope, president of the General Electric Company, will speak.

Prizes will be awarded at the third general session on Thursday morning by W. H. Onken, Jr., chairman of the prize awards committee. William A.

Civic Auditorium, San Francisco, where sessions of the N.E.L.A. convention will be held

Prendergast, former chairman of the New York Public Service Commission; W. J. Hagenah, vice-president of the Byllesby Engineering & Management Corporation; and Martin J. Insull will all speak on regulation of public utilities at the session. The finals of the national speaking contest will be held at the public relations national section session in the afternoon. B. C. Forbes, editor of *Forbes Magazine,* will deliver an address at this session and present the awards in the public relations contest.

Secretary of Commerce Robert P. Lamont will be the principal speaker at the public policy session on Thursday evening. Col. A. H. Griswold, executive vice-president of the Postal Telegraph-Cable Company and vice-president of the International Telephone & Telegraph Corporation, will discuss the subject of "Co-ordinated Communications," and Clinton B. Allsopp, vice-president of the Postal Telegraph-Cable Company, will conduct an international communication demonstration in which messages will be sent by wire and radio to London, Paris, Berlin, Manila, Shanghai, Buenos Aires and other cities, and answers will be received in a few minutes. Presentation of the Charles A. Coffin award will be made at this meeting by President Sloan, and an extensive musical program will be given. The session will be broadcast by the National Broadcasting Company over a country-wide hook-up.

At the fourth general session on Friday morning, Bernard F. Weadock, special counsel for the utilities before the Federal Trade Commission, will discuss the commission's utility investigation, and Paul M. Downing, vice-president and general manager of the Pacific Gas & Electric Company, will speak on "The Electrical Development in the West and Its Future." Following this the convention will adjourn.

▼ ▼ ▼

New Automatic Control for Mexican Plant

At the Tezcapa hydro-electric power station of the Mexican Light & Power Company, in a lonely mountainous region of Puebla, 4,570 ft. above sea level and many miles from the nearest town, automatic control gear now effects all plant operations except certain simple initiating ones, which are being carried out by a peasant attendant, employed at the station primarily for such duties as keeping the water screens free from obstruction.

The function of the station is to utilize energy from a variable water supply to generate electricity for the Necaxa-Noncolco line. Two generating sets are installed, of 3,800 kw. and 1,570 kw., respectively. The operating supply for the relays of the automatic control gear is derived from a small three-phase transformer which is connected to the high-tension line, so that the sets cannot be started unless the line is alive. When this transformer is energized the sets can be started and connected to the line by the attendant's closing small knife switches, all the various steps, including opening the main gates, running up, paralleling, synchronizing, and closing the main oil switches being performed automatically.

A system of load-indicating devices instructs the attendant what set to run according to the supply of water available. Normally, the smaller generating set is started up first. Should the amount of water become more than sufficient to run this set fully loaded a signal bell and an illuminated signal board warn the attendant to start the larger set and shut down the smaller one, and on a further increase of the supply he is warned to run both sets. Similarly, predetermined values of decreasing water supply give signals for the reduction of the amount of plant in operation.

Novel Use of Instalments in Metallurgists' Trip to U. S.

Plans for an American meeting of metallurgists, to be held by the Institute of Metals in the United States and Canada two years hence, are now taking definite shape. The American Institute of Mining and Metallurgical Engineers has prepared such an attractive draft program that nearly 100 British members have already booked for the trip. It is expected that the party from England will be joined by a large proportion of the institute's 300 American members, as well as by many members from Continental countries. The visit will include official meetings of the institute in New York and joint meetings with allied societies in Detroit and Toronto.

The party is expected to leave Southampton on Sept. 3, 1932. The meeting in New York will begin on Sept. 11, and the return journey will start from Montreal on Sept. 30. An ingenious installment system has been aranged whereby most of the cost of the trip—estimated at £120—can be paid in advance. The institute has issued printed banker's order forms under which the terms of £4 monthly can be paid as from May 1, 1930, up to June 1, 1932. Thus members taking advantage of this method of payment will, within three months of the date of sailing, have paid the major portion of the cost of the trip.

Gage Standards Advocated at A.S.A. Meeting

Establishment of national standards for pressure and vacuum gages was recommended at a general conference held in New York City on May 15 under the auspices of the American Standards Association. Thirty-five representatives of manufacturers and users of pressure and vacuum gages and of technical, governmental, and safety

bodies having an interest in such gages were present at the conference.

In accordance with the recommendations of the conference, the scope of the work will include nomenclature and definitions; rules and specifications for installation and use; method of testing; method of expressing allowable errors; accuracy requirements; capacity ratings; connections; indicator hands and stop pins; dials and graduations; bezel rings and attachments; and case sizes and mounting holes.

The conference favored, in general, the development of specifications which would tend to unify the external features of gages of the indicating types, and permit of a reasonable amount of interchangeability between the various makes.

Representatives of the steam power interests, petroleum refineries, and traction, gas, and chemical interests were particularly eager to have the standardization undertaken. Representatives of one group pointed out that at present it was necessary for them to carry in stock 72 gages of the same size to meet the demands of those to whom they sold their product.

A.I.E.E. Summer Convention at Toronto, June 23-27

This year for the first time the American Institute of Electrical Engineers will hold its annual summer convention at Toronto, Canada. With headquarters at the Royal York Hotel, the convention will run from June 23 to 27, inclusive. Eight technical sessions dealing with the following general topics are scheduled on the program: protective devices, transportation, automatic stations, transmission, insulation, communication, electrical machinery and power generation, and technical committee reports.

Included among papers dealing with power subjects are: "Centralized Control of System Operation," by J. T. Lawson; "1,000-Kw. Automatic Mercury Arc Rectifier Substation of the Union Electric Railway Company," by W. E. Gutzwiller and Otto Naef; "The 220,000-Volt System of the Hydro-Electric Commission of Ontario," by E. T. J. Brandon; "Standards of Insulation and Protection for Transformers," by J. A. Johnson and E. S. Bundy; "Effect of Voltage Surges on Rotating Machinery," by E. W. Boehne; "Vertical Shaft 25,000-Kva. Synchronous Condensers," by H. A. Ricker, J. R. Dunbar, and R. E. Day; "East River Generating Station of the New York Edison Company," by C. B. Grady, W. H. Lawrence, and R. H. Tapscott; and "Hydro Power Practice in Central Europe," by A. V. Karpov.

Entertainment features of the program include trips to the new Welland Canal, Leaside power station, and other power and manufacturing plants near Toronto; golf and tennis tournaments; a reception, banquet, and dance, and special parties for the entertainment of the ladies.

Work Gets Under Way on 200,000-Hp. Rock Island Hydro Project

THE 200,000-HP. hydro-electric development at Rock Island on the Columbia River, which Stone & Webster Engineering Corporation is designing and constructing for the Washington Electric Company, a subsidiary of the Puget Sound Power & Light Company, will be the first major development to be constructed on this stream. The remarkably high flow of the Columbia River, even in seasons of severe drought, will produce a minimum output at Rock Island materially greater than can be obtained at Muscle Shoals during the dry season.

The Rock Island power site is located about twelve miles downstream from Wenatchee, Wash., where the Columbia River is divided into two channels by the island which gives the development its name. At this point a dam will be constructed across each channel of the Columbia River, raising the water level upstream to give a maximum head of approximately 48 feet.

The dam in the west channel will consist of a gate-controlled spillway about 825 ft. long, extending from the west bank of the Columbia River to high ground on Rock Island. It will ultimately be equipped with ten crest gates 30 ft. wide x 21 ft. high, and ten crest gates 30 ft. wide x 40 ft. high. The dam in the east channel will have a free-crest spillway section extending 500 ft. eastward from high ground on Rock Island, and a gate-controlled spillway section about 550 ft. long extending from the eastern end of the free crest spillway to the river end of the power station. This spillway will ultimately be equipped with nine crest gates 30 ft. wide x 21 ft. high, and six gates 30 ft. wide x 40 ft. high.

The power house, which will extend across the greater part of the east channel but at an angle with the axis of the channel, will have a total length of about 770 ft. It will contain, initially, four 15,000-kw. generating units, located at the shore end of the power house, with provision for six additional units of similar size. The draft tube and tailrace excavation for future units will be completed with the initial stage so that no cofferdam work will be required when they are installed. Between the power house and the east bank of the river provision will be made for a further extension of the power house should such additional capacity be required in the future. Total capacity of the development may be ultimately increased to 180,000 kilowatts.

Only such gates will be installed on the spillways initially as are necessary to maintain a normal head of about 32 ft. Sufficient power will be generated by the minimum flow of the Columbia River over the head thus developed to satisfy the initial demand on the development. When the load on the station has grown sufficiently necessary gates will be added to develop a maximum head of 48 ft. The reservoir created by the dam will have an area of about 3,030 acres. Total area involved in the development is 4,600.

The initial development of 60,000 kw. will be ready for service by Aug. 1, 1932. Other hydro-electric units will be added as required, it being expected that 150,000 kw. will be in operation some time during 1937.

Airplane view of Rock Island power site, showing location of dam and power house

News of Canada

Construction work on Chats Falls development now in full swing—Manitoba renews permit on White Mud Falls project

WORK on the Chats Falls power development on the Ottawa River, about 35 miles above the Canadian Capital, is now in full swing. This development is one of the largest hydro-electric projects at present under construction in Canada. It is a joint undertaking of the Hydro-Electric Power Commission of Ontario and the Chats Falls Power Company of Quebec. The fact that the Ottawa River is an interprovincial stream, forming the boundry between the provinces of Ontario and Quebec, accounts for the division of interests. The joint power house will contain eight turbine units, each rated at 28,000 hp., or a total of 224,000 hp. Provision will also be made for the later installation of two more similar units, so that eventually the development will have a capacity of 280,000 horsepower.

To accomplish the development of this large amount of electrical power a dam three miles in length will be constructed. For about a mile of its length, on Chats Island, the dam will be an earthen section of low height. The remainder of the long structure will be built of concrete and will have 72 sluiceways to discharge the flood waters of the Ottawa River.

Though one of the longest dams ever to be constructed in Canada, the structure will nowhere be of very great height. It will follow closely the crests of the various chutes forming Chats Falls, with firm foundations provided by the reef of Laurentian rock constituting this barrier in the Ottawa River. Between the falls and the widening of the Ottawa, known as Chats Lake, about three miles above, the river falls 13 ft. in a series of rapids. These rapids will be drowned out when the dam is completed and the 50-ft. drop of the river used in the development of power.

A PRIORITY PERMIT in connection with the proposed development of power at White Mud Falls, on the Nelson River, in the province of Manitoba, issued one year ago by the Dominion Government, to the British Dominion Power Company, headed by Sir Reginald Brade, has been renewed for a further period of one year. White Mud Falls, approximately 350 miles north of Winnipeg, is one of the greatest power sites in Manitoba. During the year in which the priority permit has been held, Sir Reginald Brade and his associates have been proceeding with the study and investigation of the project preparatory to initiating a definite program of construction. These investigations will be continued during the present season.

COMING CONVENTIONS

American Society of Mechanical Engineers. Semi-Annual meeting at the Hotel Book-Cadillac, Detroit, Mich., June 9-12, 1930. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. Annual summer convention at Toronto, Canada, June 23-27. Secretary, F. L. Hutchinson, 33 West 39th St., New York City.

American Order of Steam Engineers. Annual convention and mechanical exhibit at the Grand Fraternity Building, 1626 Arch St., Philadelphia, Pa., June 9-12. Secretary, William S. Wetzler, 6033 Jefferson St., Philadelphia, Pa.

American Society of Heating & Ventilating Engineers. Annual summer meeting at the Curtis Hotel, Minneapolis, Minn., June 23-25. Secretary, A. V. Hutchinson, 33 West 39th St., New York City.

American Society for Testing Materials. Annual meeting at Haddon Hall, Atlantic City, N. J., June 23-27. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

Association of Iron and Steel Electrical Engineers. Annual convention and iron and steel exposition at Broadway Auditorium, Buffalo, N. Y., June 16-20. Managing director, John F. Kelly, Empire Building, Pittsburgh, Pa.

Canadian Electrical Association. Annual Convention at the Manoir Richelieu via the S.S. "St. Lawrence," June 11-13, 1930. Secretary, H. M. Lyster, 405 Power Building, Montreal, Quebec.

National Association of Power Engineers. Annual convention and exhibition of power machinery at the Cleveland Auditorium, Cleveland, Ohio, Sept. 8-13. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago, Ill.

National Association of Practical Refrigerating Engineers. Annual convention and exhibition at the Hotel Peabody, Memphis, Tenn., Nov. 11-14. Secretary, Edward H. Fox, 5707 West Lake St., Chicago, Ill.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Chattanooga, Tenn., June 17-19. Secretary, C. O. Myers, 14 Commercial National Bank Bldg., Columbus, Ohio.

National District Heating Association. Annual convention at the Coronado Hotel, St. Louis, Mo., June 3-6. Secretary, D. L. Gaskill, Greenville, Ohio.

National Electric Light Association. Annual convention at Municipal Auditorium, San Francisco, Calif., June 16-20, 1930. Secretary, A. J. Marshall, 420 Lexington Ave., New York City.

National Oil and Gas Power Meeting, under auspices of A.S.M.E. Oil and Gas Power Division and Pennsylvania State College, will be held at State College, Pa., June 12-14. Chairman, L. H. Morrison, c/o *Power*, 10th Ave. and 36th St., New York City.

Second Plenary World Power Conference. Convenes at Berlin, German, June 16-25. Chairman of the American Committee, O. C. Merrill, Edmunds Building, Washington, D. C.

Universal Craftsmen Council of Engineers. Annual convention at the Hotel Kimball, Springfield, Mass., Aug. 5-8. Secretary, T. H. Jones, 33 Linden Ave., Cherrydale, Va.

Personals

WILLIAM P. CREAGER, chief engineer of the Power Corporation of New York and vice-president of the Northern New York Utilities, Inc., has just returned from a two months' trip to Russia, where he made a survey of the $50,000,000 hydro-electric project on the Svir River for the Soviet Government. Representing the J. G. White Engineering Corporation, Mr. Creager made recommendations for laying the dam and power house foundations that have already been acted upon by Soviet engineers.

E. D. ALEXANDER, since 1913 vice-president of the Illinois Northern Utilities Company, has been elected president of the company to succeed Martin J. Insull, who becomes vice-chairman.

M. H. FRANK, formerly manager of the eastern division of the Wisconsin Power & Light Company, has been promoted to the newly created position of assistant to G. C. NEFF, vice-president and general manager of the company. Mr. Frank was recently elected president of the Wisconsin Utilities Association.

W. S. LEE, vice-president in charge of engineering of the Duke Power Company, Charlotte, N. C., has just been appointed chairman of the American Engineering Council Committee on the Safety of Dams. Other members of the committee are WILLIAM P. CREAGER, H. S. CROCKER, L. F. HARZA, and C. H. PAUL.

WALTER BELDING, distribution engineer of the Central Vermont Public Service Corporation, Rutland, has been elected president of the Vermont State Society of Engineers.

P. W. SWAIN, associate editor of *Power*, has been elected a director of the American Welding Society. He has also been reappointed chairman of the Meetings and Papers Committee and member of the Executive Committee. E. A. DOYLE, consulting engineer of the Linde Air Products Company, is now president of the society.

CHARLES C. CRAGIN, general superintendent and chief engineer of the Arizona Salt River Valley Water Users' Association, was unanimously elected in the annual meeting of the association, May 5, in Phoenix, to continue in his present capacity.

K. R. MACKINNON, assistant general manager of the Nebraska Power Company and vice-president of the Citizens Power and Light Company of Council Bluffs, Iowa, was recently elected president of the Middle-West Division of the National Electric Light Association. The election was held at the Middle-West Convention in Des Moines.

Business Notes

LINK-BELT COMPANY'S, Baltimore, Md., office is now located at 913 Lexington Building. H. D. Alexander is in charge of this office and Harry E. Reese handles sales.

AMES IRON WORKS of Oswego, N. Y., a division of Pierce, Butler & Pierce Manufacturing Corporation, announces that its sales and service in the Chicago territory are now in charge of E. J. Friedrich of the Cochrane Engineering Company, 1223 Monadnock Block, Chicago, Ill.

THE ELLIOTT COMPANY'S New York and Chicago district offices have recently been moved. The new addresses are: 2905 Transportation Building, 225 Broadway, New York, N. Y., and 20 North Wacker Drive, Chicago, Ill.

BROWN INSTRUMENT COMPANY, Philadelphia, Pa., announces the consolidation of its Chicago sales office and midwestern factory branch in new quarters located at 155 East Superior Street.

PENNSYLVANIA PUMP AND COMPRESSOR COMPANY, Easton, Pa., announces the appointment of E. H. Bollenbacher, 725 Forsyth Building, Atlanta, Ga., as its sales representative in the Atlanta district.

PHOENIX MANUFACTURING COMPANY, Joliet, Ill., reports that it has purchased from the Graver Corporation the latter's steel-tank, water-treating and steel-plate construction business, including the plant at East Chicago, Ind., and that it will operate this plant and business under a wholly owned subsidiary company to be known as Graver Tank & Manufacturing Corporation.

AMERICAN MANGANESE STEEL COMPANY, Chicago Heights, Ill., announces that the Southern Manganese Steel Company has become a part of its firm and will be operated as the Southern Manganese Steel Division of the American Manganese Steel Company. An office has been opened in the Law & Finance Building, Pittsburgh, with W. G. Hoffman in charge. It is also reported that John H. Coghlan has been appointed direct representative of this company in New England, with offices at 92 Broadway, Cambridge, Mass.

FOOTE BROS. GEAR & MACHINE COMPANY, Chicago, Ill., announces that at the directors' meeting held on May 12 the following additional officers of the corporation were elected: C. C. Commons, vice-president and assistant secretary; F. A. Emmons, vice-president, gear division; W. A. Barr, vice-president in charge of manufacturing; H. H. Bates, vice-president, road machinery division; W. O. Bates, Jr., assistant vice-president; W. J. Heineman, assistant vice-president; and G. G. Wennerstrom, chief engineer.

Business Healthy in Power Field

ONE of the best indicators of progress in the general power field is the productive operations maintained by the electrical equipment manufacturing plants of the country. These plants report a rate of operations during April some 7.8 per cent over March, and 6.7 per cent over April last year. The gain of April activity over that of March exceeded the normal seasonal increase for the period by about 11.3 per cent. The electrical equipment manufacturing industry is one of the few industrial groups consistently reporting 1930 operations above those of the same period in 1929, the average for the first four months being 9.1 per cent over the same period last year. Such reports indicate a healthy condition in the power field despite a current depression in general business in certain sections of the country.

Trade Catalogs

COMPRESSORS—Among the new bulletins printed by the General Electric Company, Schenectady, N. Y., is GEA-588C on Centrifugal Compressors and Geared Units.

CHAIN — A new chain information book has just been put out by the American Chain Company, Inc., Bridgeport, Conn., giving in concise form, facts and figures concerning all types of welded chain.

COOLING TOWERS—A recent publication of James M. Seymour, Inc., East Orange, N. J., describes Seymour cyclonic cooling tower for stores, hotels, offices and other industrial buildings.

OIL REFINERIES — Bulletin 120-2 issued by the Coppus Engineering Corporation, Worcester, Mass., describes the Coppus equipment for oil refineries.

HEATERS—The Venturafin method of heating for floor, wall or ceiling mounting for use with high, medium or low-pressure steam applications is described in Bulletin No. 9218 which supersedes Bulletin No. 7818 put out by the American Blower Corporation, Detroit, Mich.

INSTRUMENTS — The R. Y. Ferner Company, Investment Building, Washington, D. C., United States and Canadian agents for Chevenard dilatometers and industrial thermic analyzers is circulating a new catalog, D-1, which deals with apparatus devised by Pierre Chevenard of the laboratory at the Steel Works of Imphy, France.

BOILERS—The application and use as well as the underlying principles in the construction of Leffel Scotch marine boilers and steam engines are given in the new Bulletin No. 216 printed by The James Leffel & Company, Springfield, Ohio.

SWITCHES—Bulletin No. 830 of the Allen-Bradley Company, Milwaukee, Wis., describes an automatic pressure switch with accessories and its connection with automatic motor control for compressors, pumps, and other equipment not exceeding 150 lb. pressure.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Navy Standard	New York	$2.20 @$2.35
Kanawha	Columbus	1.35 @ 1.60
Smokeless	Cincinnati	1.90 @ 2.00
Smokeless	Chicago	1.65 @ 2.00
S. E. Kentucky	Chicago	1.25 @ 1.60
Steam	Pittsburgh	1.40 @ 1.65
Gas Slack	Pittsburgh	1.00 @ 1.25
Big Seam	Birmingham	1.50 @ 1.75

Anthracite (Gross Tons)	At Mine, for Shipment to	Price per Ton
Buckwheat	New York	$3.00 @$3.50
Barley	New York	1.25 @ 1.50

FUEL OIL

New York—May 22, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75@5.25c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c.@6.25c. per gal.

St. Louis—May 15, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.495 per bbl., or 42 gal.; 26@28 deg., $1.570 per bbl.; 28@30 deg., $1,675 per bbl.; 30@32 deg. $1.720 per bbl.; 32@36 deg., gas oil, 4.276c. per gal.; 37@40 deg., distillate, 4.98c. per gal.

Pittsburgh—May 14, f.o.b. local refinery, 30@34 deg., fuel oil, 4c. per gal.; 36@40 deg., 4@4½c.

Philadelphia — May 13, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 18 deg. plus, $1.475@$1.525 per bbl.; 23@27 deg., $2.00@$2.05 per bbl.

Cincinnati — May 13, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5.25c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.75c. per gal.

Chicago—May 13, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 75@80c. per bbl.; 26@30 deg., 85@90c. per bbl.; 30@32 deg., $1.00@$1.05 per bbl.

Boston—May 19, tank-car lots, f.o.b., 12@14 deg., Baumé, 3.3c. per gal.; 28@32 deg., 5c. per gal.

Dallas—May 17, f.o.b. local refinery 26@30 deg., $1.25 per bbl. or 42 gallons.

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Ark., Augusta—Bank of Augusta & Trust Co., will receive bids until June 2, for the construction of a pumping station for Sewer Improvement Dist. No. 1. Lund Engineering Co., Home Life Bldg., Little Rock, is engineer.

Calif., Culver City — Metro-Goldwyn-Mayer Inc., Culver City, and 1540 Broadway, New York, N. Y., plans the construction of a service building, studio, power plant, etc., here. Estimated cost to exceed $1,000,000.

Calif., Los Angeles—Borden Farm Products Co., 1950 Naomi Ave., is having plans prepared for the construction of a 1 story, 40 x 150 ft. ice manufacturing plant on 20th Ave. Private plans.

Calif., Los Angeles—City is having plans prepared for the construction of a smoke stack, 120 ft. high for power plant addition at Olive View Sanitarium.

Calif., Modesto—County of Stanislaus, is having plans prepared for the construction of a 2 story power house, as third unit of county hospital project. Estimated cost $30,000. R. C. DeLapp, 1710 Franklin St., Oakland, is architect.

Colorado—Southern Colorado Power Co., c/o W. N. Clark, Gen. Mgr., Colorado Bldg., Pueblo, is having plans prepared for additions to substations at Rocky Ford, Fowler, La Junta and Ordway, also transmission line between Ordway and Rocky Ford. Estimated total cost $150,000. Work will be done by day labor.

Colo., Paonia—Oliver Power Co., Dalta, has been granted permit to construct a power plant here.

Conn., Hamden—Connecticut Co., 185 Church St., New Haven, is having preliminary plans prepared for the construction of a power substation here. Estimated cost $40,000. R. W. Foote, 185 Church St., New Haven, is engineer.

Conn., Torrington — Charlotte Hungerford Hospital, awarded contract for the construction of a power house and laundry to Torrington Building Co., Main St. Estimated cost $125,000.

Ind., Garrett—City received lowest bid for the construction of a 3 story, 45 x 70 ft. power house, including equipment from W. A. Sheets Construction Co., Fort Wayne. Estimated cost $47,000.

Md., Baltimore—Bd. of Awards, will receive bids until June 4 for the construction of a 1 story, 46 x 129 ft. pumping station at Druid Hill Park. E. G. Rost, Municipal Bldg., is water engineer.

Md., Baltimore—New National Hotel Corp., c/o L. E. Sholtes and E. W. Darling, 907 15th St. N. W., Washington, D. C., Archts., plans the construction of a 6 story apartment hotel, including steam heating and refrigeration systems, elevators, etc., at University Parkway and 40th St. Estimated cost $600,000.

Mass., Charlestown (br. Boston) — Bureau Yards & Docks, Navy Dept., Washington, D. C., plans the construction of a power plant, at Navy Yard, here. Estimated cost $68,000. Private plans.

Mass., Concord—Edison Electric Illuminating Co., 39 Boylston St., Boston, is receiving bids for the construction of a power substation at Main St. and Nine Acre Rd., here. Estimated cost $50,000. Bigelow, Wadsworth, Hubbard & Smith, 11 Beacon St., Boston, are architects and engineers.

Mich., Portland—Town is having plans prepared for the construction of a municipal hydro-electric power plant. Estimated cost $68,000. Holland, Ackerman & Holland, 53 West Jackson Blvd., Chicago, Ill., Engrs., are receiving bids May 26 for one 400 and one 200 hp. vertical d.c. electric units and on other work later.

Minn., St. Paul — Northern States Power Co., R. F. Pack, V. Pres. and Gen. Mgr., 15 South 5th St., Minneapolis, will soon award contract for a 6 story office building, including steam heating system, etc., at 5th and Wabasha Sts. Estimated cost $600,000. Ellerbe & Co., Minnesota Bldg., St. Paul, are architects.

Mo., St. Louis—Bd. of Education, 911 Locust St., will soon receive bids for the construction of a 4 story, 101 x 150 ft. shop building at 3400 Thomas St., also 1 story, 70 x 150 ft. power house on School St. G. W. Sanger, Acting Comr. of Bldgs.

Mo., St. Louis—Syndicate, c/o R. H. McRoberts, 1508 Paul Brown Bldg., will receive bids about June 3, for the construction of a 16 story apartment building, including steam heating system, electric elevators, etc., at Skinker Blvd. and Southwood Ave. Estimated cost $1,200,000. F. G. Avis, 1019 Big Bend Blvd., Richmond Heights, is architect.

N. J., Hackettstown — Centenary Collegiate Institute, Church St., is having preliminary plans prepared for the construction of a boiler house on Church St. Estimated cost $40,000. F. W. Wentworth, 140 Market St., Paterson, is architect.

N. J., Teaneck—Holy Name Hospital, Teaneck Rd., awarded contract for the construction of a 4 story addition to hospital to J. L. Bried, West St., Englewood. Estimated cost $800,000. Steam heating, ventilation and refrigeration systems, boilers, elevators, etc. will be installed.

N. Y., Dannemora—Dept. of Correction, State Office Bldg., Albany, awarded contract for the construction of a power house at Clinton Prison here, to J. McCambley Co., 12 Margaret St., Plattsburg. $128,917.

N. Y., New York — New York Polyclinic Medical School & Hospital, 341 West 50th St., plans addition to hospital including boiler room, new boilers, smoke breeching equipment, etc. Estimated cost $150,000. W. S. Gregory, 180 Madison Ave. and Wyeth & King, 18 East 48th St., are architects.

O., Cleveland—Dept. of Public Utilities, E. H. Krueger, Dir., City Hall, will receive bids until May 29, for the construction of a 67 x 74 ft. boiler house and 23 x 23 ft. ash bunker at Warrensville Farm. Estimated cost $50,000. F. H. Cover, 502 City Hall, is engineer.

Tex., San Antonio—Bd. of Education, c/o J. A. McIntosh, Pres., is having plans prepared for the construction of heating plants for twelve schools. Estimated cost $80,000. Phelps & DeWees, 628 Gunter Bldg., are architects.

Wash., Anacortes—W. C. Morse Co., Smith Tower, Seattle, Engrs., will receive bids until June 1, for extension to waterworks including pumping station at Abon, 24 in. main to Whistle Lake, reservoir, etc., for City. Estimated cost $500,000.

Wash., Tacoma—Bd. of Contracts & Awards, will soon award contract for construction complete with appurtenances of the superstructure for Cushman power house No. 2 near Potlatch in Mason County. Estimated cost $350,000.

Ont., London—Huron & Erie Mortgage Corp., M. Aylesworth, Gen. Mgr., will receive bids until June 10 for the construction of a 9 story office building, including steam heating system, four elevators, etc., on Dundas St. Estimated cost $1,000,000. Watt & Blackwell, 286 Dundas St., are architects.

Ont., Toronto—Dept. of Public Works, Parliament Bldgs., plans a 6 story addition to East Block Offices, Parliament Buildings, including steam heating system, etc. Estimated cost $1,000,000. F. R. Heakes, Parliament Bldgs., is architect.

Quebec—Beauharnois Power Corp., awarded contract for four 50,000 and two 8,000 hp. vertical electric generator for power plant to Canadian General Electric Co., 212 King St. W., Toronto.

Equipment Wanted

Engines and Generator Equipment — Yale, Okla.—F. Tolson, Clk., will receive bids until June 9 for one 400 and one 675 hp. Diesel engines and generator equipment. Estimated cost $30,000.

Pump — Kingston, Ont. — Kingston Public Utilities Commission, City Hall, will soon receive bids for the installation of a 7 m.g.p.d. motor driven centrifugal pump for proposed waterworks. Estimated cost $20,000.

Pump—Lachine, Que.—City plans to purchase a high and low pressure motor driven pump.

Pumping Equipment—Ossining, N. Y.—Bd. of Water Commissioners, S. G. Ellegood, Secy., will receive bids until June 2, for low lift and auxiliary pumping equipment for proposed waterworks improvements.

Pumps—East Orange, N. J.—Bd. of Water Comrs., City Hall, will receive bids until June 2, for pumps at Canoe Brook and Braidburn well field on the water reserve in connection with waterworks. Estimated total cost $45,000.

Pumps and Pumping Equipment — County Commissioners, Court House, will receive bids until June 5 for pumps and pumping equipment for proposed sewage disposal plant. Estimated cost $75,000.

Transformers — Cleveland, O. — City will receive bids until May 29, for 169 distribution transformers, etc. for municipal light plant.

Transformers—Dundas, Ont.—Hydro-Electric Power Commission of Ontario, 190 University Ave., Toronto, plans the installation of three 15,000 kw. outdoor type transformers at Dundas substation.

Industrial Projects

Calif., Santa Monica—Douglas Aircraft Inc., manufacturers of airplanes, awarded contract for a 40 x 240 ft. addition to factory to L. B. Norman, 1323 Georgina Ave.

Calif., Stockton—Le Tourneau Mfg. Co., Moss St., manufacturers of road building equipment, plans the construction of a factory at North Wilson Way. Estimated cost to exceed $40,000.

Ill., Chicago—Aridor Co., 589 East Illinois St., awarded contract for masonry and carpentry for a 2 story, 132 x 350 ft. factory for the manufacture of caps for glass containers, etc., at 3228-3240 West 48th Pl. Estimated cost $125,000.

Ill., Peoria—Morrison Label & Carton Co., Irving Ave. and Decatur St., Brooklyn, N. Y., awarded contract for a 1 and 2 story factory at Galena Rd. and Peoria St., to W. M. Allen, Son & Co., Jefferson Bldg. Estimated cost $50,000.

Mich., Dearborn—Ford Motor Co., is having plans prepared for the construction of a 1 story glass plant at River Rouge. Estimated cost $50,000. Giffels & Vallet, 604 Marquette Bldg., Detroit, are architects. Machinery and equipment will be required.

N. J., Jersey City—Jersey City Ladder Co. Inc., 677 Montgomery St., will soon award contract for a 2 story, 45 x 140 ft. factory at Crawfoot St. Estimated cost $40,000. B. Senger, 926 Bergen Ave., is architect.

N. J., Linden—Commercial Steel Equipment Corp., 1024 Elizabeth Ave., Elizabeth, is having revised plans prepared for a 1 story factory here. Estimated cost $40,000. A. J. Silberstein, 868 Broad St., Newark, is architect.

O., Chillicothe — Chamber of Commerce, awarded contract for a 1 story, 75 x 350 ft. factory on McArthur St. to D. E. Gardner Co., Portsmouth. Estimated cost $50,000. Stearns-Auer Shoe Co., 7th and North Sts. is lessee.

O., Cleveland—The E. F. Hauserman, 6800 Grant Ave., manufacturers of steel partitions, had plans prepared for a 2 story, 80 x 270 ft. factory. Estimated cost $150,000. G. S. Rider Co., Marshall Bldg., is architect.

O., Cleveland—U. S. Air Compressor Co., 5300 Harvard Ave., is receiving bids for a 1 story, 100 x 150 ft. addition to factory. Estimated cost $60,000. G. S. Rider Co., Marshall Bldg., is architect.

O., East Palestine—Adamson Mfg. Co., plans the construction of a 1 story, 50 x 260 ft. factory for the manufacture of steel tanks for gasoline storage on East Clark St. Estimated cost $40,000. Private plans.

Pa., Philadelphia — Broun Instrument Co., Roberts and Wayne Sts., plans a 2 story, 79 x 219 ft. addition to factory. Ballinger & Co., 12th and Chestnut Sts., are architects.

Pa., Pittsburgh—Keystone Box Co., M. H. Nolan, Pres. and Treas., 28th and Smallman Sts., will soon award contract for a 1 story, 20 x 100 ft. factory. P. Dietz, 611 Penn Ave., is architect and engineer.

Texas—Phillips Petroleum Co., Bartlesville, Okla., plans the construction of a natural gasoline plant, including two distillation units and 21 unit compressor plant of 4,095 hp. in Gray County, Tex. Estimated cost $350,000. Work will be done by owner's forces.

W. Va., Moundsville — Fostoria Glass Co., had plans prepared for a 4 story, 90 x 140 ft. factory. Estimated cost $100,000. Lockwood, Greene & Co., Hanna Bldg., Cleveland, O., are architects.

Wis., Milwaukee—G. H. Smith Steel Casting Co., 500 Clinton St., manufacturers of pressed steel, awarded contract for a 1 story, 149 x 202 ft. machine shop and assembly plant at Chase and Holt Sts., to The Austin Co., 510 North Dearborn St., Chicago, $34,500.

B. C., Victoria—Sidney Roofing & Paper Co., plans the construction of a plant for the manufacture of insulating board from waste material from cedar shingle mills. Estimated cost $200,000.

Ont., Etobicoke Township—Ontario Vitrified Products Co., 34 King St. E., Toronto, plans the construction of a plant, including kilns, equipment, etc., on Salisbury Ave. near Lake Shore Rd., here. Estimated cost $50,000. Private plans.

Ont., Kingston—Canadian Terminals Systems, 34 King St. E., Toronto, plans the construction of a grain elevator, 2,500,000 cu. capacity here. Estimated cost $1,500,000. H. A. Johnston, 34 King St. E., Toronto, is engineer. Conveying and grain handling equipment will be required.